Vulnerable Carina Anatomy and Ostial Lesions in the left Anterior Descending Coronary Artery After Floating-Stent Treatment

Alfonso Medina,[a] Pedro Martín,[a] Javier Suárez de Lezo,[a] Celestina Amador, [a] José Suárez de Lezo,[b] Manuel Pan,[b] Francisco Melián,[a] Enrique Hernández,[a] Luis Burgos,[a] Soledad Ojeda,[b] José Ramón Ortega,[a] and Antonio García[a]

[a]Servicio de Cardiología, Hospital Doctor Negrín, Universidad de Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Las Palmas, Spain
[b]Servicio de Cardiología, Hospital Reina Sofía, Universidad de Córdoba, Córdoba, Spain

Introduction and objectives. Percutaneous coronary intervention for ostial lesions of the left anterior descending coronary artery (LAD) remains a complex procedure. The aim of this study was to evaluate the usefulness of a method of treatment that we have termed the floating-stent approach.

Methods. The study involved 71 patients with ostial LAD lesions who underwent implantation of a drug-eluting stent in the LAD, which totally or partially covered the ostium of the circumflex artery. No further interventions were planned. Intravascular ultrasound was performed both at baseline and after treatment in 49 patients. All were followed up clinically (16 [12] months).

Results. Angiography of the LAD demonstrated an immediate success rate of 100%. However, significant focal damage was observed in the circumflex ostium in 7 (10%) patients, 3 of whom needed treatment. The mean protrusion of the stent over the origin of the circumflex artery was 2.48 (0.91) mm. The only predictor of circumflex ostial injury identified in the study was the carina having a spiky appearance on intravascular ultrasound, visible in the longitudinal view. We termed this feature the "eyebrow sign." Carina displacement was responsible for the focal damage in 13 of the 14 patients with this feature. Overall, the major cardiac adverse event rate during follow-up was 4%.

Conclusions. Use of the floating-stent technique for treating LAD ostial lesions was straightforward and gave excellent medium-term results. Intravascular ultrasound showed that patients who had a carina with specific vulnerable anatomical features were predisposed to circumflex artery ostial injury.

Key words: Stent. Ostial. Bifurcation. Carina. Intravascular ultrasound.

Anatomía vulnerable de la carina en lesiones ostiales de la arteria coronaria descendente anterior tratadas con *stent* flotante

Introducción y objetivos. El tratamiento percutáneo de las lesiones ostiales de la arteria coronaria descendente anterior (DA) es complejo. El propósito de este estudio es valorar la utilidad de una estrategia de tratamiento que denominamos *stent* flotante.

Métodos. Se estudió a 71 pacientes con estenosis ostial de la DA tratados mediante el implante de un *stent* farmacoactivo en la DA, cubriendo parcialmente el origen de la arteria circunfleja (Cx), sin planificar manipulaciones ulteriores. Se realizó un estudio ultrasónico basal y tras tratamiento en 49 pacientes. Se hizo seguimiento clínico prospectivo en todos los pacientes (16 [12] meses).

Resultados. El éxito angiográfico inmediato en la DA fue del 100%. Se observó daño focal significativo en el ostium de la Cx en 7 (10%) pacientes, de los que 3 precisaron tratamiento. El grado de protrusión del *stent* cubriendo el origen de la Cx fue de 2,48 ± 0,91 mm. En el estudio de predictores de daño del *ostium* de la Cx, se identificó la presencia de un patrón ultrasónico de la carina, visible en la reconstrucción longitudinal que, por su forma puntiaguda, denominamos «signo de la ceja». Su desplazamiento fue la causa del daño en 13 de los 14 pacientes. La suma de eventos cardiacos mayores al seguimiento fue del 4%.

Conclusiones. La técnica del *stent* flotante en el tratamiento de las lesiones ostiales de la DA es simple, con excelente resultado a medio plazo. El estudio ultrasónico identifica a los pacientes con una anatomía vulnerable de la carina, predictora del daño en la arteria circunfleja.

Palabras clave: Stent. *Ostial. Bifurcación. Carina. IVUS.*

ABBREVIATIONS

Cx: circumflex artery
DES: drug-eluting stent
IVUS: intravascular ultrasound
LAD: left anterior descending coronary artery
LMCA: left main coronary artery

INTRODUCTION

Percutaneous treatment of left anterior descending coronary artery (LAD) ostial lesions is complex and remains a focus of research. The therapeutic objective is to guarantee the stent totally covers plaque in the coronary ostium, minimizing possible damage in other bifurcation segments.[1-3]

Since the introduction of drug-eluting stents (DES)[4,5] for left main coronary artery (LMCA) bifurcation, 2 simple strategies seem to have dominated treatment of this lesion type.[6] One consists of stent implantation to simultaneously cover the ostial LAD lesion, origin of the circumflex artery (Cx) and, to a greater or lesser extent, distal LMCA. This entails a further planned intervention to adapt the proximal portion of the stent to the bifurcation and the LMCA, usually by the simultaneous inflation of two balloons (the kissing balloon technique).[7] The other strategy consists of implanting a stent to cover the LAD ostium with minimal protrusion in the area of the carina.[8,9]

Pretreatment intravascular ultrasound (IVUS) is considered extremely useful[9,10] because it facilitates identification of significant disease in the distal LAD of patients in whom angiography underestimates the degree of stenosis at this level and who therefore require a different percutaneous treatment.

Prior to the introduction of DES, when conventional stents were deployed, the techniques used aimed to diminish plaque volume prior to implantation through directional[11] or rotational[12] atherectomy, in an attempt to reduce the restenosis rate. However, results tended to be inadequate. The radical reduction of hyperplasia that DES provide has made these techniques redundant except in truly exceptional cases (eg, patients with massive calcification of the lesion).

The objective of the present study is to determine the usefulness of an approach to the treatment of LAD ostial lesions that we term the floating-stent technique. It consists of implanting a DES in the proximal LAD to partially cover the origin of the Cx without further planned interventions (Figure 1).
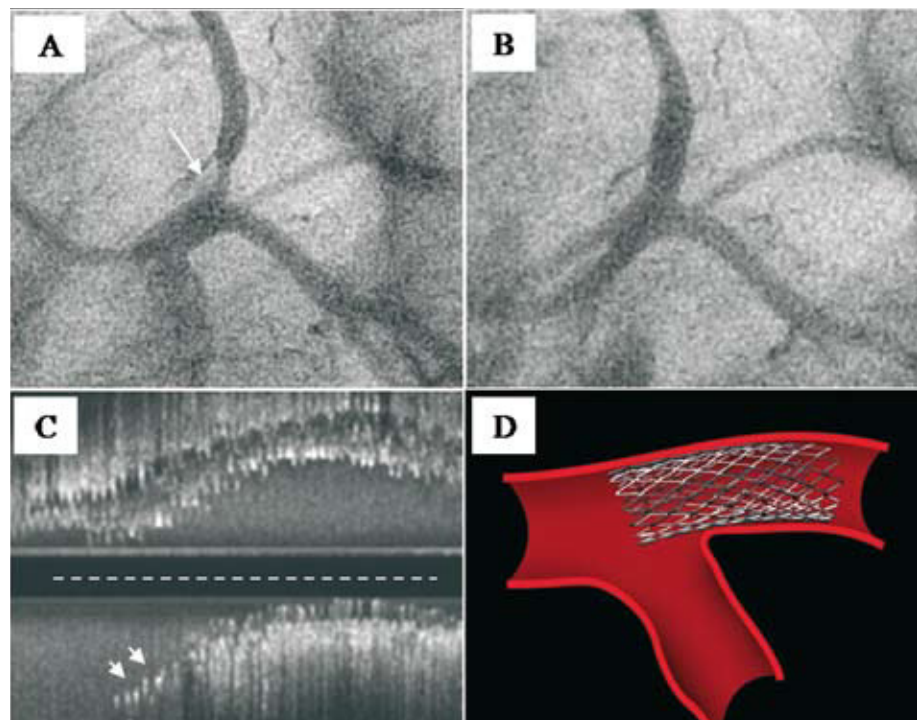

Figure 1. A: LAD ostial lesion (arrow) viewed in LAO-CAU projection. B: angiographic results after floating-stent implantation. C: ultrasound results (longitudinal view) showing stent proximal cells covering Cx origin (arrows). At the level of the contracarina, the stent covers the entire lesion. Note the IVUS catheter trajectory (broken line), out-of-line with respect to the proximal LAD segment axis. D: drawing of floating-stent.

METHODS

Patients

Between February 2002 and September 2008, we treated 71 patients with native LAD ostial lesions (Medina's LMCA classification[13] {0,1,0}) by implanting a floating DES to totally cover the LMCA ostium and partially cover the Cx ostium, without needing further planned interventions. Medina's classification assigns a binary value (1,0) depending on whether or not bifurcation segments are affected: LMCA (principal proximal vessel), LAD (principal distal vessel), and Cx (secondary branch). We excluded patients with minimal disease at the level of the distal LMCA and ostial Cx and 21 patients with similar lesions who, during the first 2 years of the study, received a stent covering the distal LMCA and proximal LAD segments. Patient clinical characteristics are in Table 1.

Diagnostic Cardiac Catheterization and IVUS

All patients underwent femoral approach diagnostic catheterization, 30° right anterior oblique ventricular angiography, and multiple sequential coronary angiography projections. The angiographic inclusion criterion was presence of a significant de novo proximal LAD lesion (>50% stenosis) affecting the ostium or the first 3 mm of the ostium. We excluded patients presenting concomitant angiographic LMCA and/or proximal Cx infection. In all patients we calculated tapering[14] (quotient obtained by dividing the LAD reference diameter by the LMCA diameter). Baseline angiographic findings are in Table 2.

Forty-nine (69%) patients underwent baseline and post-implantation ultrasound studies (Atlantis SR, Boston Scientific, 2.5 Fr, 40 MHz, or Avanar F/X, Volcano Therapeutics Inc., 2.9 Fr, 20 MHz) with motorized withdrawal at 0.5 mm/s from the distal LAD segment of reference to the LMCA ostium. Nineteen (38%) of these also underwent baseline ultrasound Cx studies. Before withdrawal, 200 µg intracoronary nitroglycerin was administered. We measured external elastic lamina area, luminal area and plaque load at three levels: distal segment of reference, segment of maximum stenosis and distal LMCA. We calculated the remodeling index (external elastic lamina area at the level of the ostium/ external elastic lamina area in the distal segment of reference). Simultaneously, we studied the carinal area in detail (ie, the confluence of distal LMCA, Cx origin, and LAD origin) and analyzed atheromous plaque distribution and carina morphology through a longitudinal reconstruction permitting optimal visualization of the bifurcation. After stent implantation, we analyzed LAD ostium scaffolding characteristics and the degree of stent protrusion in the Cx. Table 3 shows baseline ultrasound findings.

Angiographic and ultrasound characteristics indicate substantial differences in vessel caliber between distal LMCA and proximal LAD (tapering, 0.73 [0.1]). The LAD/Cx angle was 95° (38°). Ultrasound analysis of the pathologic mechanism of stenosis at the level of the LAD ostium revealed predominantly negative remodeling in the lesion (remodeling index, 0.80 [0.21]).

The Floating-Stent Implantation Technique

We implanted the stent using a left anterior oblique projection with caudal angulation, and adapted the double angle to patient anatomy. Stent diameter was chosen as a function of distal LAD reference diameter. In all patients, the stent-deploying balloon proximal radio-opaque marker was positioned proximal to the angiographic carina (LAD/Cx angle) to guarantee complete LAD ostium scaffolding even though this implied some protrusion of the stent at the level of the Cx origin. Contrast images were recorded with the stent in the pre-implantation

TABLE 1. Patient Clinical Characteristics (n=71)

Age, mean (SD), y	62 (12)
Men	49 (69)
High blood pressure	41 (58)
Diabetes mellitus	22 (31)
Dyslipidemia	37 (52)
Active smoker	20 (28)
Previous PCI	12 (17)
Unstable angina or AMI	57 (80)
Multivessel CAD (≥2 vessels)	29 (41)
Ejection fraction, mean (SD), %	56 (10)

AMI indicates acute myocardial infarction; CAD, coronary artery disease; PCI, percutaneous coronary intervention.
Data are expressed as mean (SD) or n (%).

TABLE 2. Baseline Angiographic Characteristics (n=71)

Lesion length, mm	13.8 (5.1)
LMCA diameter, mm	4.37 (0.7)
LAD reference diameter, mm	3.24 (0.24)
Minimum luminal diameter, mm	1.02 (0.41)
Stenosis, %	69 (11)
Proximal Cx diameter, mm	3.18 (0.55)
LAD-Cx angle	95° (38°)
LMCA-LAD angle	136° (26°)
Dominant Cx, n (%)	11 (15)
Tapering	0.73 (0.1)

Cx indicates circumflex artery; LAD, left anterior descending coronary artery; LMCA, left main coronary artery; Tapering, LAD reference diameter/LMCA diameter.

TABLE 3. Baseline Ultrasound Characteristics (n=49)

Distal LMCA	
EEL area, mm²	21.42 (4.75)
Luminal area, mm²	15. (4.41)
Plaque load, %	26 (11)
Ostial LAD	
EEL area, mm²	11.54 (4.55)
Luminal area, mm²	3.51 (1.64)
Plaque load, %	58 (17)
LAD reference segment	
EEL area, mm²	14.56 (4.68)
Luminal area, mm²	9.39 (3.48)
Plaque load, %	35 (10)
Index of remodeling (ostium)	0.80 (0.21)
Absence of plaque in the carina, % (n/N)	73 (36/49))

Cx indicates circumflex artery; EEL, external elastic lamina; Index of remodeling, EEL ostium area/reference distal EEL area; LAD, left anterior descending coronary artery; LMCA, left main coronary artery.

position. Initial stent inflation pressure was 15 atm. During balloon occlusion, contrast was injected to visualize LMCA and Cx. In patients with ultrasound studies, we also took contrast images of the IVUS transductor when LAD, carina and Cx were visible. We used these to guide subsequent positioning of the stent-deploying catheter balloon proximal marker (Figure 2). We performed post-implantation angiographic and IVUS studies. In most patients, stent implantation was without predilatation. Eleven (15%) of 71 patients underwent short balloon stent post-dilatation at the level of the LAD ostium, respecting the floating-stent segment at the level of the carina. Procedure data are in Table 4.

Drug-eluting stents administered sirolimus in 24 (34%) patients, paclitaxel in 11 (15%), everolimus in 25 (35%), and zotarolimus in 11 (15%). During the procedure, patients received 100-200 IU/kg sodium heparin, which was totally or partially neutralized with protamine after the procedure[15]; they then received 10 000 U of dalteparin/day (10-30 days). All patients received double antiplatelet therapy with aspirin and clopidogrel for ≥1 year.

Angiographic measurements were with CMS 7.1 software (MEDIS, The Netherlands). All angiographic and ultrasound measurements were made off-line by 2 expert interventional cardiologists.
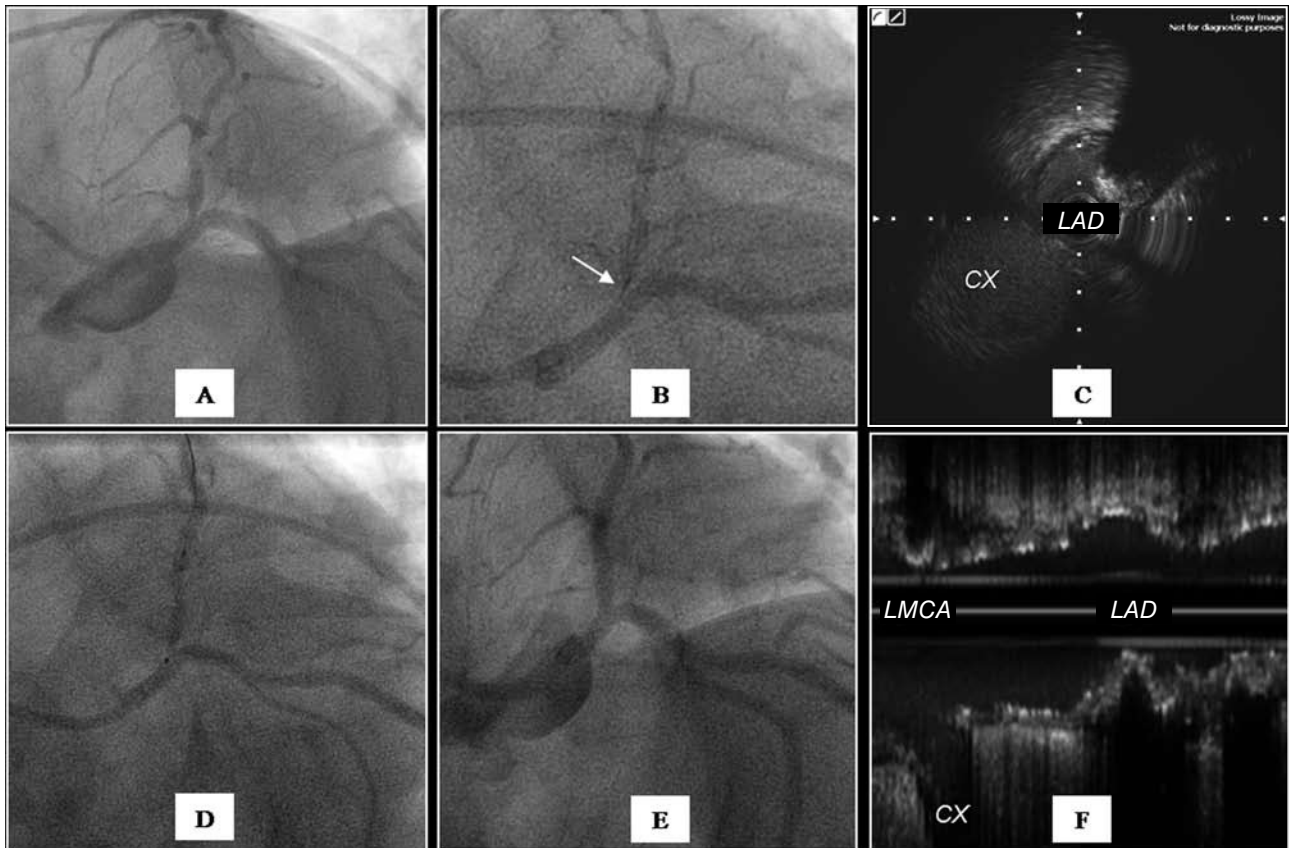

Figure 2. A: LAO-CAU projection angiography showing ostial lesion at the level of the LAD. B: angiography in the same projection showing the IVUS transductor (arrow) at the level of the ultrasound carina. C: transversal ultrasound view showing the carina. D: angiography showing the position of the stent before implantation; the proximal marker of the balloon is positioned with reference to the IVUS transductor. E: angiographic result after stent implantation. F: ultrasound result showing minimal protrusion at the level of the carina and complete covering of the contracarina.

TABLE 4. Therapeutic Procedure Characteristics (n=71)

IVUS	49 (69)
Direct stent	52 (73)
Need for rotablator	1 (1)
Post-dilatation LAD	11 (15)
Number of stents per lesion (LAD)	1.15 (0.36)
Stent diameter, mm	3.25 (0.36)
Stent length, mm	20.11 (7.83)
Mean inflation pressure, atm	16.6 (1.5)
Counterpulsation balloon	1 (1)
Use of anti-IIb/IIIa (Reopro)	5 (7)
Patients with revascularization of other lesions	37 (52)

IVUS indicates intravascular ultrasound; LAD, left anterior descending coronary artery.

All patients underwent periodic clinical follow-up by telephone or in-clinic.

Statistical Study

Quantitative variables are expressed as mean (SD) and qualitative data as percentages. We compared independent data means with the Student *t* test and qualitative variables with χ^2. We considered $P < .05$ to be statistically significant. Statistics were calculated with SPSS 15.0.

RESULTS

Angiographic Findings

Immediate procedure success at the level of the LAD was 100%, with minimum 3 (0.42) mm luminal diameter after implantation and 8% (5%) residual stenosis. In no patient did the stent protrude in the LMCA beyond the Cx ostium so post-dilatation was not required at this level.

We found focal angiographic disease in the Cx ostium in 19 (27%) patients. This was mild in most cases and significant (residual stenosis >50%) in only 7 (10%). In these patients, the decision to intervene at this level was at the discretion of the operator and consisted of balloon dilatation in 2 (3%) and stent implantation at the level of the Cx ostium in 1 (1%). Five of these 7 patients were studied with a pressure guidewire and all of them registered a >0.85 fractional flow reserve. Figure 3 illustrates this.

Ultrasound Findings

Longitudinal reconstruction IVUS showed absence of plaque at the level of the carina in 36 (73%) of our 49 patients. Ultrasound carina morphology revealed a subgroup of 14 patients (28%) with a spiky carina, reflecting an initially short trajectory parallel to LAD and Cx medial walls and producing a characteristic ultrasound image we have termed the "eyebrow sign" (Figures 4 and 5). In the 49 patients, the stent totally covered the LAD ostium. At the level of the carina we found a protrusion of the stent (2.48 [0.91] mm) covering the Cx origin to a greater or lesser extent. However, opposite the carina, the stent adapted exactly to the LAD ostium and totally covered the plaque at this level without protruding in the LMCA. No patient presented damage at the level of the LMCA.

We analyzed angiographic and ultrasound variables that might predict damage at the level of the Cx ostium (Table 5). No significant differences appeared in angiographic parameters between patients with and patients without Cx ostial damage, including LAD-Cx angle amplitude. The only predictor of Cx ostial damage was presence of the "eyebrow sign" in the aforementioned longitudinal IVUS (Figure 5). Of 14 patients who presented this, 13 had disease in the Cx origin after implantation ($P < .01$).

Follow-up

The major cardiac event rate was 4% (95% confidence interval [CI], 0.01-1.17). Post-procedure, we recorded non-Q wave infarction (cardiac enzyme elevation more than twice normal) in 2 patients during hospitalization. During follow-up, 1 patient underwent angioplasty for focal restenosis in the LAD. Two patients with clinical recurrence were reevaluated by angiography, which revealed correct positioning of the stent in the LAD but disease progression at other levels. Two patients were reevaluated by catheterization and the stent studied with optical coherence tomography,[16] showing a pattern of endothelization in the floating stent cells similar to the portion of the stent in apposition to the LAD wall (Figure 6). In 16 (12) months mean follow-up, we recorded no deaths or late stent thrombosis.

DISCUSSION

Floating-Stent

Percutaneous treatment with DES is an alternative to surgery in symptomatic patients with arteriosclerosis of the LAD ostium.[8,9] In the era of the conventional stent, treatment of these lesions was controversial due to the high restenosis rate, which was not reduced by combining stenting with prior resectioning of plaque volume.[1,11] With the arrival of the DES, this strategy was abandoned.
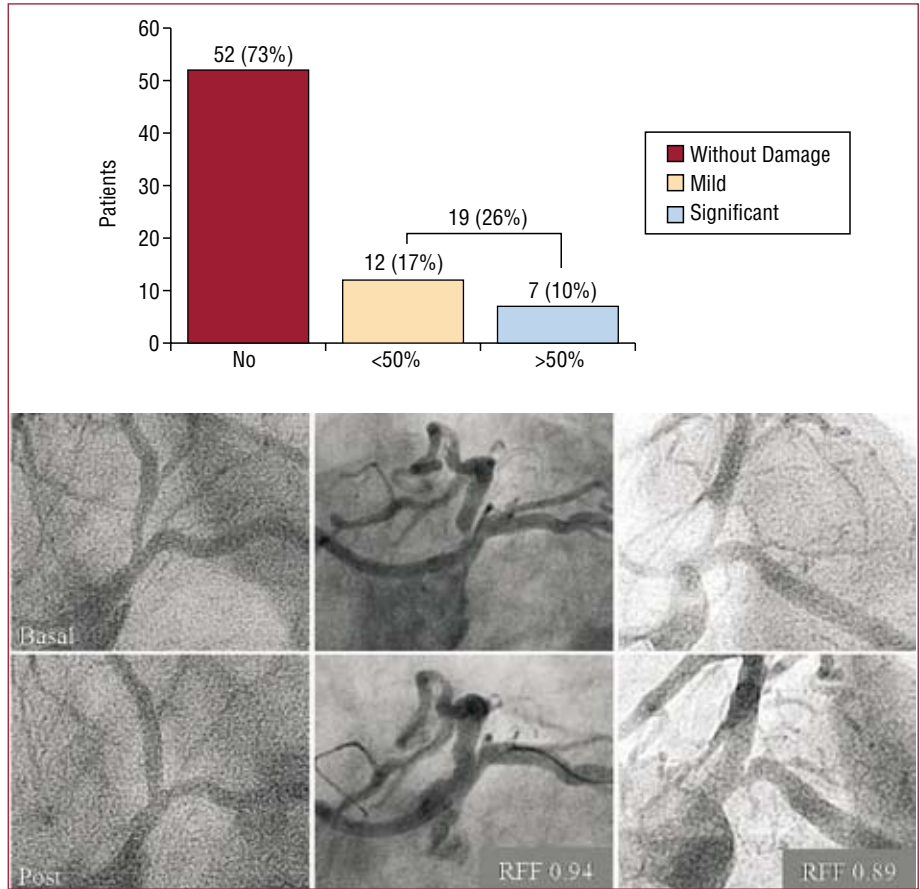
Figure 3. Above, a bar chart illustrating incidence of damage in the Cx ostium. Only 10% of cases present >50% residual focal stenosis. Below, baseline angiography (upper row) and post-treatment angiography (lower row) of 3 patients with no damage in the Cx (left), mild Cx ostium disease (center) and significant Cx ostium disease (right). RFF indicates fractional flow reserve.
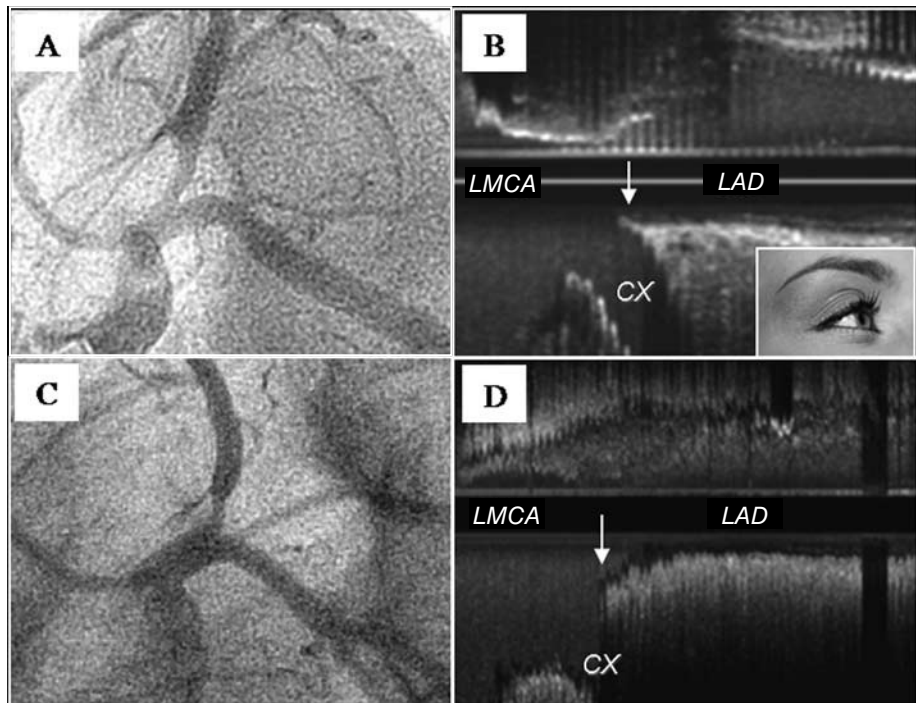

Figure 4. A: angiography of ostial LAD lesion in LAO-CAU projection. B: baseline (longitudinal reconstruction) ultrasound study of the lesion illustrated in A showing, at the level of the carina, the initial parallel trajectory of the medial wall of the LAD and the Cx (arrow); we have termed this peculiar spiky morphology the "eyebrow sign"; note the absence of plaque at the level of the carina. C: another ostial LAD lesion with angiographic characteristics similar to those illustrated in A. D: ultrasound study of the lesion illustrated in C showing the carina without the "eyebrow sign" (arrow). This patient, like most of those in our series, presents no plaque at the level of the carina.
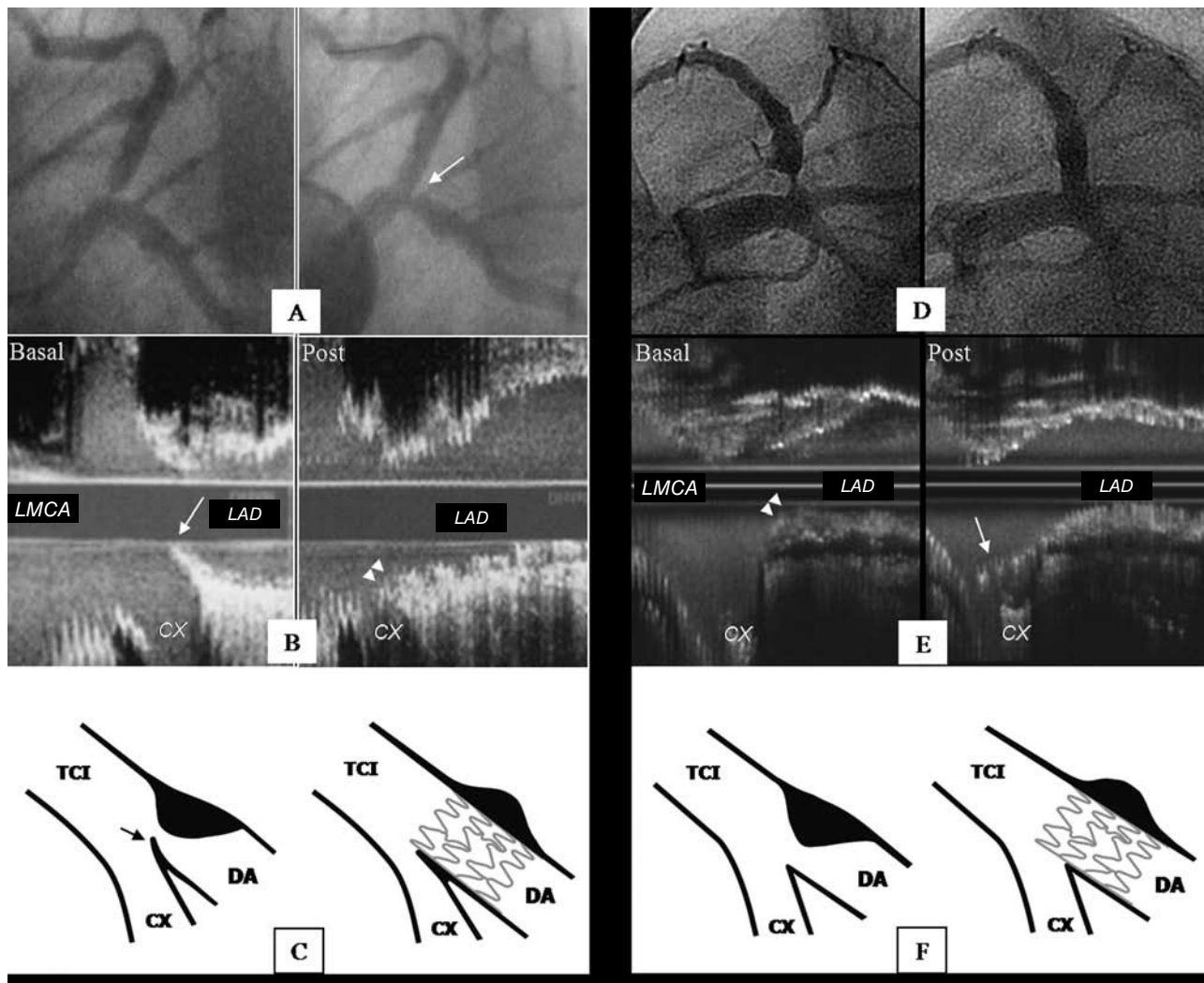
Figure 5. The panel on the left shows a patient with ostial LAD lesion and vulnerable carina anatomy (presence of the "eyebrow sign"). A: baseline and post-treatment angiography; the arrow indicates focal damage induced in the Cx origin after stent implantation. B: baseline and post-treatment ultrasound studies showing the "eyebrow sign" (arrow) and carina displacement (arrow heads). C: drawing illustrating (on the left) lesion with the "eyebrow sign" (arrow); on the right, showing how the stent, protruding in the carinal area, displaces the carina and affects the Cx ostium. The panel on the right shows another patient with favorable carina anatomy. D: baseline and post-treatment angiography showing no Cx ostium disease. E: IVUS examination showing the carina without the "eyebrow sign"; in this patient, note the presence of plaque in the carina (arrow heads); post-treatment, the stent partially covers the Cx origin (arrow) and totally covers the plaque at the level of the contra-carina. F: drawing illustrating the lesion and how the stent adapts to the carinal area without damaging the Cx ostium.

Our study shows the usefulness of a simple technique aimed at guaranteeing total covering of the LAD ostium. Although this entails limited protrusion of the stent into the carinal area, ultrasound findings indicate protrusion is limited to the Cx ostium. The positive clinical evolution of our patients suggests the presence of floating cells in the carinal area has no long-term negative impact.

An alternative approach to adjusting stent implantation to the LAD ostium[17] consists of advancing the stent over 2 guidewires (LAD and Cx) after inserting the proximal end of a guidewire previously positioned in the Cx through the most proximal stent cell. We consider this complex, not without potential complications, and believe it has not been proven that it guarantees covering the LAD ostium in the contra-carina.

Cubeddu et al[7] question strategies of adjusting the stent to the LAD ostium due to the potential risk of not totally covering the lesion. They propose implanting a stent to cover the distal LMCA, Cx origin and proximal LAD lesion followed by further kissing balloon interventions to adapt the stent to the

TABLE 5. Analysis of Possible Angiographic (n=71) and Ultrasound (n=49) Predictors of Damage in the Circumflex Artery Ostium

	Cx With Disease (n=19)	Cx Without Disease (n=52)	P
LAD-Cx angle	88.63º (36.46º)	96.88º (39.09º)	.42
LMCA diameter, mm	4.31 (0.54)	4.40 (0.76)	.66
LAD diameter, mm	3.24 (0.42)	3.23 (0.45)	.95
Cx diameter, mm	3.41 (0.59)	3.10 (0.51)	.10
Stenosis, %	68.53 (12.83)	69.25 (11.63)	.83
Stent diameter, mm	3.24 (0.37)	3.26 (0.36)	.82
Plaque load, %	56 (19)	60 (16)	.58
Minimum luminal area, mm²	3.64 (1.11)	3.56 (1.27)	.98
EEL area, mm²	11.41 (4.97)	11.6 (4.41)	.90
Index of remodeling	0.72 (0.23)	0.85 (0.19)	.07
Presence of "eyebrow sign"	13	1	<.01
Protrusion of stent in Cx ostium, mm	2.8 (1.6)	2.3 (1.5)	.18

Cx indicates circumflex artery; EEL, external elastic lamina; LAD, left anterior descending coronary artery; Index of remodeling, EEL ostium area/ distal EEL area of reference; LMCA, left main coronary artery.
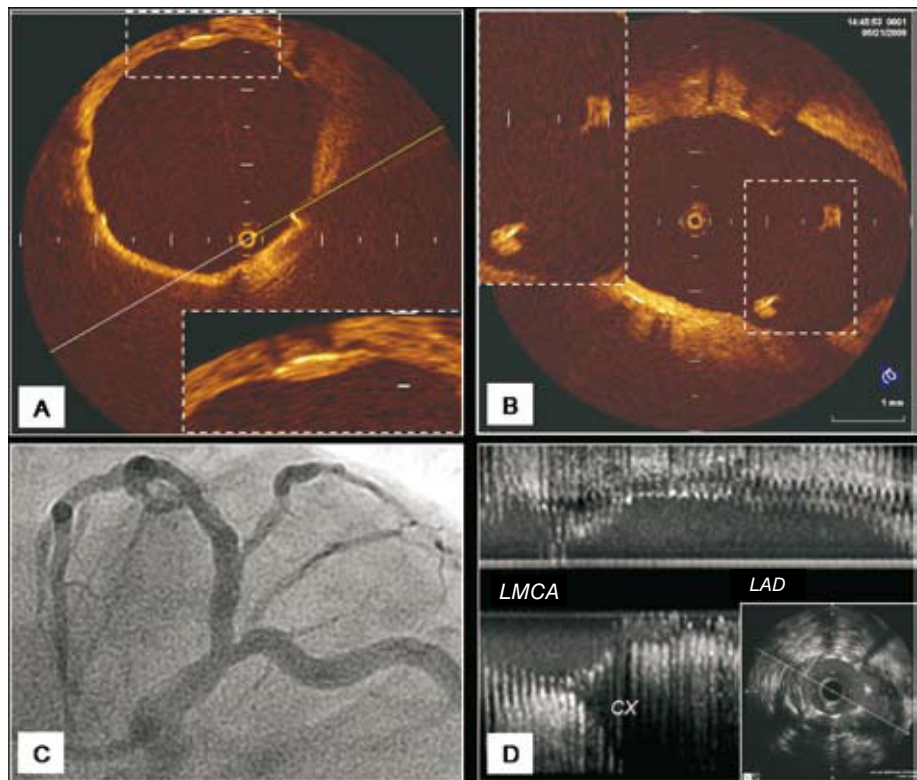

Figure 6. A, B: optical coherence tomography 7 months post-treatment; pattern of stent endothelization in contact with the wall is similar to that observed when the stent floats in the carinal area. C, D: angiography and ultrasound study of this patient.

different components of the bifurcation, reporting good results for this approach.

In contrast, the floating-stent technique is simpler and seems to offer good results too. We believe our strategy avoids both incorporating metal in a disease-free segment such as the LMCA, and the need for post-dilatation to achieve correct positioning. Moreover, it avoids the barotrauma this maneuver can produce in the Cx.

The "Eyebrow Sign" as a Predictor of Circumflex Artery Ostial Damage

In LAD ostial lesions, no clear evidence exists of an anatomical configuration unfavorable to stenting. Angiographic information on this seems limited. However, only baseline IVUS can analyze certain specific anatomic details. Longitudinal reconstruction clearly identifies the presence of

a spiky carina (the "eyebrow sign"), apparently predicting Cx ostial damage after implantation in the LAD. Stent-induced displacement of this type of carina produced focal indentation in the Cx origin with angiographic patterns that were always similar (Figures 4 and 5). Incidence of this sign in our study is low. However, in patients with this vulnerable anatomy, damage in the side branch ostial could be limited by choosing a stent diameter adjusted to the distal reference of the LAD, thus minimizing carina displacement. When damage occurs in the side branch ostial, as the stent partially covers the Cx origin it permits a guidewire to pass through one of the cells. Low atmosphere balloon dilatation facilitates damage correction through repositioning the carina, but the kissing balloon technique is not employed to avoid barotrauma in the distal LMCA, which is not protected by the stent. In patients in whom this type of carina is very prominent, it may be better to use a different strategy and implant a stent covering the distal LMCA and the proximal portion of the LAD (stent across) to facilitate secondary branch access. We must stress that the "eyebrow sign" is only found in longitudinal reconstruction IVUS, so diagnosis is impossible unless the ultrasound study of the bifurcation shows carina anatomy.

Finally, another ultrasound observation we consider relevant in our series is the documentation of absence of plaque at the level of the carina in most patients (73%). This contradicts previous hypotheses attributing Cx ostial lesions to stent-induced plaque displacement.[18,19]

Limitations

This descriptive feasibility study lacks a control group. Consequently, we cannot compare the results obtained with those of other techniques. We have no angiographic follow-up of asymptomatic patients treated with the floating-stent technique although, given the localization of the lesion, we believe adverse events are unlikely to occur with no clinical warning. Ideally, our study would include more patients and a longer follow-up.

CONCLUSIONS

Implantation of a floating-stent in the percutaneous treatment of ostial LAD lesions, without disease at the level of the distal LMCA and Cx origin, is a simple technique with a low adverse event rate in the mid-term follow-up. With this technique, the frequency of significant induced damage in the Cx ostium is low (10%). Baseline longitudinal reconstruction IVUS of the bifurcation can identify those patients with consistent vulnerable carina anatomy through the presence of a characteristic pattern (the "eyebrow sign"). This predicts focal angiographic disease in the Cx ostium after floating-stent implantation. The stent appears to displace the carina and induce stenosis. Finally, baseline IVUS shows low incidence of plaque in the carina.

REFERENCES

1. Park SJ, Lee CW, Hong MK, Kim JJ, Park SW. Stent placement for ostial left anterior descending coronary artery stenosis: acute and long-term (2-year) results. Catheter Cardiovasc Interv. 2000;49:267-71.
2. Asakaura Y, Takagi S, Ishikawa S, Asakura K, Sueyoshi K, Sakamoto M, et al. Favorable strategy for the ostial lesion of the left anterior descending coronary artery: influence on narrowing of circumflex coronary artery. Catheter Cardiovasc Diagn. 1998;43:95-100.
3. de Cesare NB, Bartorelli AL, Galli S, Loaldi A, Fabbiocchi F, Sganzerla P, et al. Treatment of ostial lesions of the left anterior descending coronary artery with Palmaz-Schatz coronary stent. Am Heart J. 1996;132:716-20.
4. Morice MC, Serruys PW, Sousa JE, Fajadet J, Ban Hayashi E, Perin M, et al. A randomized comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. N Engl J Med. 2002;346:1773-80.
5. Moses JW, Leon MB, Popma JJ, Fitzgerald PJ, Holmes DR, O'Shaughnessy C, et al. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. N Engl J Med. 2003;349:1315-23.
6. Pan M, Suárez de Lezo J, Medina A, Romero M, Segura J, Ramírez A, et al. A stepwise strategy for the stent treatment of bifurcated coronary lesions. Catheter Cardiovasc Interv. 2002;55:50-7.
7. Cubeddu RJ, Wood FO, Saylors EK, Mann T. Isolated disease of the ostium left anterior descending or circumflex artery: management using a left main stenting technique. Clinical outcome at 2 years. J Invasive Cardiol. 2007;19:457-61.
8. Tsagalou E, Stankovic G, Iakovou I, Melzi G, Cosgrave J, Ge L, et al. Early outcome of treatment of ostial de novo left anterior descending coronary artery lesions with drug-eluting stents. Am J Cardiol. 2006;97:187-91.
9. Seung KB, Kim YH, Park DW, Lee BK, Lee CW, Hong MK, et al. Effectiveness of sirolimus-eluting stent implantation for the treatment of ostial left anterior descending artery stenosis with intravascular ultrasound guidance. J Am Coll Cardiol. 2005;46:787-92.
10. Kim YH, Hong MK, Lee SW, Lee CW, Han KH, Kim JJ, et al. Randomized comparison of debulking followed by stenting versus stenting alone for ostial left anterior descending artery stenosis: intravascular ultrasound guidance. Am Heart J. 2004;148:663-9.
11. Airoldi F, Di Mario C, Stankovic G, Briguori C, Carlino M, Chieffo A, et al. Clinical and angiographic outcome of directional atherectomy followed by stent implantation in de novo lesions located at the ostium of the left anterior descending coronary artery. Heart. 2003;89:1050-4.
12. Kishi K, Hiasa Y, Tomokane T, Yamaguchi K, Ogura R, Miyajima H, et al. Efficacy of stenting after rotational atherectomy for ostial LAD and ostial LCX stenosis in patients with diabetes. J Invasive Cardiol. 2005;17:14-8.
13. Medina A, Suárez de Lezo J, Pan M. Una clasificación simple de las lesiones coronarias en bifurcación. Rev Esp Cardiol. 2006;59:183.

14. Banka VS, Baker HA 3rd, Vemuri DN, Voci G, Maniet AR. Effectiveness of decremental diameter balloon catheters (tapered balloon). Am J Cardiol. 1992;69:188-93.
15. Pan M, Suárez de Lezo J, Medina A, Romero M, Hernández E, Segura J, et al. In-laboratory removal of femoral sheath following protamine administration in patients having intracoronary stent implantation. Am J Cardiol. 1997;80:1336-8.
16. Gerckens U, Lim VY, Grube E. Tomografía de coherencia óptica en la evaluación de las endoprótesis coronarias con capacidad de liberación de fármacos. Rev Esp Cardiol. 2005;58:1469.
17. Wong P. Two years experience of a simple technique of precise ostial coronary stenting. Catheter Cardiovasc Interv. 2008;72:331-4.
18. Poerner TC, Kralev S, Voelker W, Sueselbeck T, Latsch A, Pfleger S, et al. Natural history of small and medium-sized side branches after coronary stent implantation. Am Heart J. 2002;143:627-35.
19. Furukawa E, Hibi K, Kosuge M, Nakatogawa T, Toda N, Takamura T, et al. Intravascular ultrasound predictors of side branch occlusion in bifurcation lesions after percutaneous coronary intervention. Circulation. 2005;69:325-30.