Coronary Stent Immobilization During Angioplasty by Transcoronary Ventricular Pacing Via a Guidewire

Garikoitz Lasa,[a] Mariano Larman,[a] Koldo Gaviria,[a] Juan Carlos Sanmartín,[a] Mario Sádaba,[b] and José Ramón Rumoroso[b]

[a]Servicio de Hemodinámica y Cardiología Intervencionista, Policlínica Gipuzkoa, San Sebastián, Guipúzcoa, Spain
[b]Servicio de Hemodinámica, Hospital de Galdakao, Galdakao, Vizcaya, Spain

Introduction and objectives. In some patients, cardiac contractions cause the coronary artery segment adjacent to a stent to move in such a way that accurate stent positioning is difficult. A number of techniques have been described for immobilizing the stent at the target site by inducing periods of either asystole or tachycardia. This study shows how pulsatile motion can be controlled by means of rapid ventricular pacing via an angioplasty guidewire.

Methods. The study involved 27 consecutive patients in whom excessive stent movement during angioplasty complicated accurate stent implantation. In these selected patients, myocardial tachycardia was induced by transcoronary ventricular pacing via an angioplasty guidewire with the aim of reducing the pulsatile motion of the stent.

Results. At baseline, the median displacement was 4.08 mm (interquartile range, 2.75 mm). During pacing at 100 and 150 beats per minute, the median displacement was 1.39 mm and 0.54 mm, respectively (interquartile range, 1.66 mm and 0.54 mm, respectively). Transcoronary myocardial pacing was effective in 96% of cases. No complications associated with pacing were reported.

Conclusions. Transcoronary ventricular pacing via an angioplasty guidewire was an effective and safe method for achieving stent immobilization in cases where there was excessive pulsatile motion.

Key words: *Angioplasty. Pulsatile motion. Immobilization. Ventricular pacing. Transcoronary. Guidewire.*

Inmovilización del *stent* coronario durante la angioplastia mediante estimulación ventricular transcoronaria con guía terapéutica

Introducción y objetivos. La contracción cardiaca genera en ocasiones un desplazamiento de la arteria coronaria sobre el *stent* que puede dificultar su precisa implantación. Se han descrito varias técnicas para inmovilizar el *stent* en la posición deseada mediante la inducción de periodos tanto de asistolia como de taquicardia. Este estudio muestra cómo este fenómeno de vaivén es controlable mediante la estimulación ventricular eléctrica rápida a través de la guía terapéutica de angioplastia.

Métodos. Se ha seleccionado de manera consecutiva a 27 pacientes en los que durante la angioplastia el excesivo desplazamiento del *stent* dificultaba su correcta implantación. En los casos seleccionados, se taquicardiza el miocardio mediante estimulación eléctrica ventricular de forma transcoronaria a través de la guía terapéutica para lograr una reducción del desplazamiento en vaivén del *stent*.

Resultados. El desplazamiento presenta una mediana en situación basal de 4,08 (intervalo intercuartílico, 2,75) mm. Durante la estimulación a 100 y 150 lat/min, el desplazamiento presenta una mediana de 1,39 y 0,54 (intervalos intercuartílicos, 1,66 y 0,54) mm, respectivamente. La estimulación miocárdica transcoronaria ha sido eficaz en el 96% de los casos. No se han observado complicaciones en relación con la estimulación eléctrica.

Conclusiones. La estimulación ventricular transcoronaria a través de la guía terapéutica es un método efectivo y seguro para inmovilizar el *stent* en caso de desplazamiento de vaivén.

Palabras clave: *Angioplastia. Vaivén. Inmovilización. Estimulación ventricular. Transcoronaria. Guía terapéutica.*

INTRODUCTION

Coronary stent angioplasty is the treatment of choice for coronary artery disease in a large proportion of cases. However, stent placement is not free of difficulties or complications and correct implantation can be hindered by the stent's

Correspondence: Dr. G. Lasa.
Servicio de Hemodinámica y Cardiología Intervencionista. Policlínica Gipuzkoa.
P.º Miramón, 174. 20009 San Sebastián-Donostia. Guipúzcoa. España.
E-mail: glasa@med.policlinicagipuzkoa.com

Received February 15, 2008.
Accepted for publication December 16, 2008.

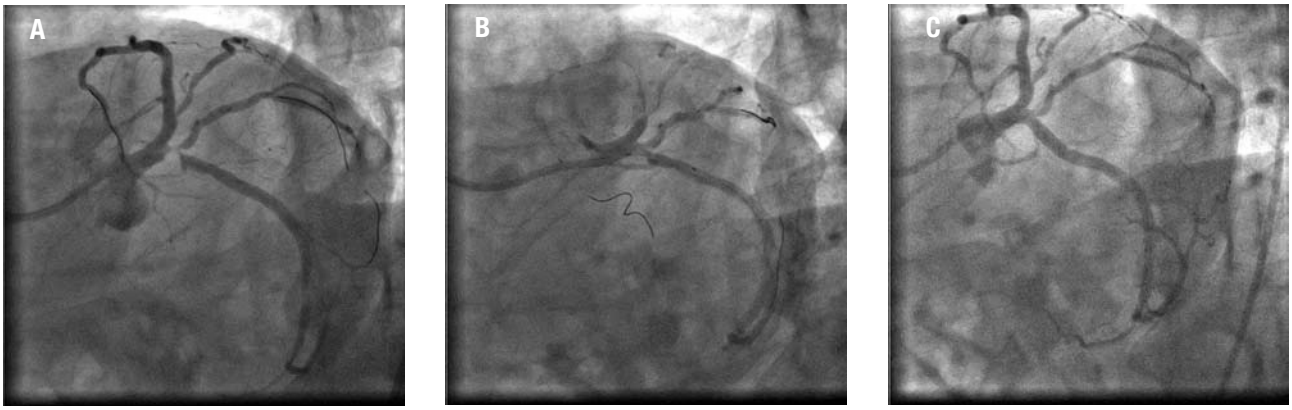

Figure 1. The sequence of images shows the lesion treated. A: prior to dilatation. B: during positioning with pacing at 150 beats/min. C: final outcome.

pulsatile movements. Such movement can also lead to later complications. Ventricular contraction and relaxation is transmitted to the epicardial coronary arteries, so that it is not unusual for a stent to suffer from a longitudinal antegrade and retrograde "hum or buzz" which hampers correct positioning.

In this context, stent displacement during angioplasty can adversely affect the outcome of the procedure, particularly in situations where placement needs to be very precise. This study shows how tachycardia induced using the intracoronary guidewire reduces stent displacement due to cardiac contraction and allows for accurate implantation.

METHODS

Induction of tachycardia via intracoronary guidewire is used in our center if the interventionist considers that longitudinal stent displacement might inhibit correct implantation. This study describes a consecutive series of cases in which the technique was used. In each case, it was decided to use the technique after visual inspection by the interventionist indicated displacement of the stent along the artery. A total of 27 patients were included from May 2007 through to January 2008. Particular emphasis was placed on selecting cases in which pulsatile movement led to ostial or bifurcation lesions, although the technique was used in all cases requiring precise positioning of the stent to avoid complications arising from incorrect placement. Stent displacement was measured by recording the maximum amplitude of the displacement, regardless of the time cycle in which it occurred. In most cases, a proximal lateral branch was used as the reference and the minimum and maximum distance to the stent was quantified using coronary arteriography. It was occasionally necessary to use other stable anatomical references (proximal plates or calcium images, among others).

Tachycardia was induced in all cases and angiographic controls obtained while pacing at 100 and 150 beats/min. The stent was then relocated in the desired position (Figure 1) using the same principles applied when permanent pacemakers are functioning in monopolar mode. The guidewire therefore acts as a negative electrode or cathode (the role performed by the distal end of the pacemaker electrode) and the skin acts as the positive electrode or anode (the role performed by the pacemaker casing). The battery of the temporary external pacemaker is connected to the clips, which act as extension leads. The battery has 2 wires or poles (anode and cathode, positive and negative, or red and black, respectively), and the clip acting as the cathode is connected to the guidewire. The clip acting as the anode is connected to the Abbocath needle which is inserted under the skin. Our usual practice is to traverse the subcutaneous tissue with the Abbocath for 1 cm in the previously anesthetized area close to the introducer (Figure 2). Pacing begins at a slightly higher frequency than patient's baseline (5 V). When there is no evidence of failure to capture in a 10-15 s interval, the frequency is increased to 100 and 150 beats/min and a control angiography is performed at both frequencies. The frequency giving the best response is selected. When failure to capture is observed at 5 V, the voltage is increased to 10 V and the same procedures are followed.

We performed a descriptive analysis of the study variables. Qualitative variables were described in terms of frequency distributions. Quantitative variables showing a normal distribution were described using means (standard deviations [SD]) and those with a non-normal distribution were described using medians [interquartile range] or the 25-75 percentile. The Kolmogorov-Smirnov test was used to test the normality of the distributions. Mean observed deviations were compared using Student

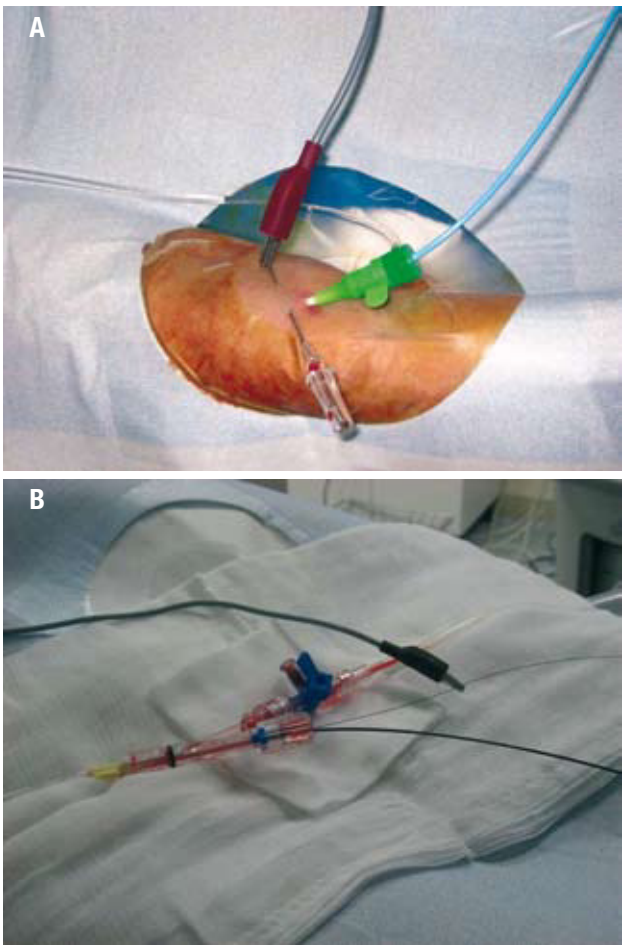

Figure 2. A: the pacemaker battery's positive terminal or anode is connected to the Abbocath, which is inserted into the skin. B: the pacemaker battery's negative terminal or cathode is connected to the angioplasty guidewire.

TABLE 1. **Baseline Characteristics of the Population**

Patients, n	27
Age, mean (SD), y	54.4 (10.3)
Indication, n (%)	
Stable angina	11 (40)
ACSWST	11 (40)
ACSST	5 (18)
Vessel, n (%)	
Anterior descending	12 (44)
Circumflex	9 (33)
Right coronary	5 (18)
LCT	1 (3)
Segment, n (%)	
Proximal	16 (59)
Medial	5 (18)
Distal	1 (3)
Ostial	4 (14)
Bifurcations, n (%)	20 (74)
Reference diameter, mean (SD), mm	3.01 (0.82)
Extent of injury, mean (SD), mm	13.24 (5.97)
Calcium, n (%)	6 (22)
Angulation, n (%)	10 (37)
Tortuosity, n (%)	8 (29)
Thrombus, n (%)	5 (18)
Predilatation, n (%)	16 (59)
Minimal luminal diameter, median [interquartile range], mm	1.22 [0.62]
Drug-eluting stent, n (%)	13 (48)]

ACSST indicates acute coronary syndrome with ST segment elevation; ACSWST, acute coronary syndrome without ST segment elevation; LCT, left common trunk; SD, standard deviation.

t test for independent measures. All statistical analyses were performed using SPSS 15.0 software.

RESULTS

Over the 8 months of the study period, transcoronary electrical pacing was performed in a total of 27 patients in which pulsatile movement hindered correct placement of the stent. These represented 3% of the 826 consecutive angioplasties performed in that period. Mean age in the study patients was 54.4 (10.3) years. Forty percent were referred with a diagnosis of stable angina, 40% with acute coronary syndrome without ST segment elevation, and 18% for acute coronary syndrome with ST segment elevation. The vessel treated was the anterior descending in 44% of cases, the circumflex in 33%, the right coronary in 18%, and the left common trunk in 1 (3%). The proximal segment was treated in 59% of cases, the medium segment in 18%, and the distal segment in 3%. Lesions were ostial in 14% of cases (in any of the coronary vessels) and bifurcation lesions were present in 74% of cases. The mean vessel diameter was 3.01 (0.82) mm and mean lesion length was 13.24 (5.97) mm. The presence of calcium was noted in 22% of cases, angulation in 37%, tortuosity in 29%, and thrombus in 18%. Balloon predilatation was performed in 59% of patients. The median minimal luminal diameter prior to stent implantation was 1.22 [0.62] mm. Drug-eluting stents were implanted in 48% of cases (Table 1). Median displacement was 4.08 [2.75] mm at baseline, 1.39 [1.66] mm during stimulation at 100 beats/min, and 0.54 [0.54] mm during stimulation at 150 beats/min. Differences were statistically significant at $P<.001$ (Table 2). In 62% of cases, 10 V pacing was used due to failure to capture at 5 V. Assuming an acceptable outcome as one in which displacement is <1 mm, stimulation at 100 beats/min achieved success in 37% of cases, whereas stimulation at 150 beats/min achieved success in 96% of cases. Implantation was considered successful in all cases. The only case in which stimulation at 150 beats/min did not achieve a successful result

TABLE 2. **Results**

Baseline displacement, mm	4.08 (2.75)	
Displacement at 100 beats/min, mm	1.39 (1.66)	*P*<.001
Displacement at 150 beats/min, mm	0.54 (0.54)	
Theoretical success at 100 beats/min, n (%)	10 (37)	
Theoretical success at 150 beats/min, n (%)	26 (96)	
Successful implantation, n (%)	27 (100)	
Stent length, mm	15 [6]	

Values are medians (interquartile range), except where otherwise indicated.

was due to intermittent failure to capture despite the use of voltages >10 V. Stimulation was equally effective using either hydrophilic or non-hydrophilic guidewires (Wisp and BMW respectively, Abbott Laboratories, Illinois, USA). Symptomatic electrical stimulation of the diaphragm occurred in 11% of cases and electrical sensation at the puncture site in 7% of cases.

DISCUSSION

Intracoronary stent displacement can lead to anomalies in the implantation of the device and have serious consequences, particularly in the treatment of ostial and bifurcation lesions. Poor positioning of the stent can mean it fails to cover all plate segments and can lead to the presence of stent cells at the main branch when treating ostial injuries or proximal segments of lateral branches. It can also lead to the presence of prosthetic material in healthy coronary segments. In some cases, poor positioning of the stent may mean a second stent is needed to cover the entire target plate. Some studies have indicated an association between stent length and thrombosis and restenosis rates, so that the greater the length of the stent, the greater the risk of complications.[1,2] In practice, therefore, the smallest feasible amount of prosthetic material is used to cover the stenotic segment. Any of these situations can lead to a suboptimal outcome and increase the rate of complications resulting from poor implantation.

Various techniques have been described to stabilize the stent. The best known are rapid pacing via transvenous catheter stimulation of the right ventricle,[3,4] induction of asystole through adenosine administration, balloon inflation at the main branch, placement of a second, parallel guidewire,[5] or the Szabo technique,[6] among others. Right ventricular pacing using catheters is not without complications. Ventricular perforation and cardiac tamponade are serious complications of this procedure.[7] It can also cause complications, such as bruising or fistulae, at the vascular access. Other disadvantages of this technique are the increased procedure time required and the greater use of material resources. Using adenosine to induce asystole periods also has some disadvantages. First, the duration of the induced asystole is short and unpredictable. This can lead to the emergence of a heartbeat during implantation with subsequent displacement of the stent and the occurrence of complications or an undesirable final outcome. Secondly, adenosine should be used with caution in asthmatic patients. Both of these aspects limit the technique's practical usefulness. Balloon inflation at the main branch and the placement of a second parallel guidewire are alternative techniques that have shown limited effectiveness and applicability.

Angioplasty guidewire pacing has been described as a technique for controlling bradyarrhythmias during cardiac catheterization or angioplasty.[8-10] Transcoronary stimulation using guidewires is not susceptible to the adverse effects associated with these techniques.[11,12] We did not observe any complications associated with this mode of stimulation. Tachycardia was induced safely and effectively and, using a temporary pacemaker, achieves the same results as right ventricular pacing, thus avoiding the need for central venous catheterization. In comparison with drug-induced asystoles, transcoronary pacing has a longer-lasting effect and avoids possible side effects from these drugs. The time required to commence stimulation is significantly less than in the case of transvenous stimulation and is similar to that required for the administration of adenosine. In a small number of patients, the technique produces electrical stimulation of the diaphragm or a mild electrical sensation at the puncture site which is somewhat unpleasant, but its short duration means it is well-tolerated. Self-limiting coronary spasms associated with similar techniques have been described, but we did not observe any cases here. In contrast to slow stimulation (100 beats/min), rapid stimulation (150 beats/min) was effective in 96% of cases ($P<.001$) and stent deployment was considered successful in all cases. It was not necessary to use more than one guidewire to improve capture, nor to use pacing voltages >10 V. We observed some capture defects but these were resolved after repositioning the guidewire or slightly increasing the threshold for stimulation.

In terms of study limitations, the number of patients included was small and the results were obtained in a single center. We also did not analyze the final disposition of the stent or the occurrence of clinical events, and we did not undertake patient follow-up.

CONCLUSIONS

Transcoronary ventricular pacing via an angioplasty guidewire was an effective and safe method for achieving stent immobilization in cases where there was excessive pulsatile motion. This method is simpler, cheaper, and safer than those described previously in the literature. It can be applied in any interventional cardiology unit without the need for additional material or a long learning period.

REFERENCES

1. de la Torre-Hernández JM, Alfonso F, Hernández F, Elizaga J, Sanmartín M, Pinar E, et al. ESTROFA Study Group. Drug-eluting stent thrombosis: results from the multicenter Spanish registry ESTROFA (Estudio ESpañol sobre TROmbosis de stents FArmacoactivos). J Am Coll Cardiol. 2008;51:986-90.
2. Goldberg SL, Loussararian A, de Gregorio J, Di Mario C, Albiero R, Colombo A. Predictors of diffuse and aggressive intra-stent restenosis. J Am Coll Cardiol. 2001;37:1019-25.
3. O'Brien DG, Smith WH, Henderson RA. Stabilisation of coronary stents using rapid right ventricular pacing. Eurointerv. 2007;3:235-8.
4. Okamura A, Ito H, Iwakura K, Kawano S, Kurotobi T, Koyama Y, et al. Rapid ventricular pacing can reduce heart motion and facilitate stent deployment to the optimal position during coronary artery stenting: initial experience. Eurointerv. 2007;3:239-42.
5. Katoh O, Reifart N. New double wire technique to stent ostial lesions. Cathet Cardiovasc Diagn. 1997;40:400-2.
6. Kern MJ, Ouellette D, Frianeza T. A new technique to anchor stents for exact placement in ostial stenoses: the stent tail wire or Szabo technique. Catheter Cardiovasc Interv. 2006;68: 901-6.
7. Nashed G, French B, Gallagher D, Hopkins A, Juergens C, Leung D, et al. Right ventricular perforation with cardiac tamponade associated with use of a temporary pacing wire and abciximab during complex coronary angioplasty. Catheter Cardiovasc Interv. 1999;48:388-9.
8. Chatelain P, Meier B, Bélenger J, Killisch JP, Cox JN, Rutishauser W. Emergency cardiac pacing via a coronary vessel during percutaneous coronary angioplasty. Arch Mal Coeur Vaiss. 1985;78:1583-7.
9. Meier B, Rutishauser W. Coronary pacing during percutaneous transluminal coronary angioplasty. Circulation. 1985;71: 557-61.
10. Meier B. Coronary pacing for bradycardia during balloon angioplasty. N Engl J Med. 1984;311:800.
11. Heinroth KM, Stabenow I, Moldenhauer I, Unverzagt S, Buerke M, Werdan K, et al. Temporary trans-coronary pacing by coated guidewires: a safe and reliable method during percutaneous coronary intervention. Clin Res Cardiol. 2006;95:206-11.
12. Mixon TA, Cross DS, Lawrence ME, Gantt DS, Dehmer GJ. Temporary coronary guidewire pacing during percutaneous coronary intervention. Catheter Cardiovasc Interv. 2004;61: 494-500.