Original article

IVUS Findings in Late and Very Late Stent Thrombosis. A Comparison Between Bare-metal and Drug-eluting Stents

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A B S T R A C T

Introduction and objectives: Stent thrombosis (ST) is a life-threatening complication after stent implantation. Intravascular ultrasound is able to discern most causes of ST. The aim of this study was to compare intravascular ultrasound findings between bare-metal stents (BMS) and drug-eluting stents (DES) in patients with late (31 days to 1 year) or very late ST (> 1 year).
Methods: Of 250 consecutive patients with late or very late ST in 7 Spanish institutions, 114 patients (45.5% BMS and 54.5% DES) were imaged with intravascular ultrasound. Off-line intravascular ultrasound analysis was performed to assess malapposition, underexpansion, and neoatherosclerosis.
Results: The median time from stent implantation to ST was 4.0 years with BMS and 3.4 years with DES (P = .04). Isolated malapposition was similarly observed in both groups (36.5% vs 46.8%; P = .18) but was numerically lower with BMS (26.6% vs 48.0%; P = .07) in patients with very late ST. Isolated underexpansion was similarly observed in both groups (13.5% vs 11.3%; P = .47). Isolated neoatherosclerosis occurred only in patients with very late ST and was more prevalent with BMS (22.9%) than with DES (6.0%); P = .02. At 2.9 years' follow-up, there were 0% and 6.9% cardiac deaths, respectively (P = .06) and recurrent ST occurred in 4.0% and 5.2% of patients, respectively (P = .60).
Conclusions: Malapposition was the most common finding in patients with late and very late ST and is more prevalent with DES in very late ST. In contrast, neoatherosclerosis was exclusively observed in patients with very late ST and mainly with BMS.

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Hallazgos por IVUS en trombosis de *stent* tardía y muy tardía. Comparación entre *stents* metálicos y farmacoactivos

R E S U M E N

Introducción y objetivos: La trombosis de *stent* (TS) es una complicación grave tras la angioplastia coronaria, y la ecografía intravascular es una herramienta capaz de discernir las causas. El objetivo es comparar los hallazgos por ecografía intravascular entre *stents* metálicos (SM) y *stents* farmacoactivos (SFA) en pacientes con TS tardía (de 31 días a 1 año) o muy tardía (>1año).
Métodos: Se incluyó a 114 pacientes (el 45,5% con SM y el 54,5% con SFA) de un total de 250 consecutivos con TS tardía o muy tardía en 7 hospitales españoles. Se realizó una ecografía intravascular, que se analizó posteriormente para detectar la presencia de malaposición, infraexpansión y neoateroesclerosis.
Resultados: El tiempo hasta la TS fue de 4,0 años en los SM y 3,4 años en los SFA (p = 0,04). La malaposición fue similar en ambos grupos (el 36,5 frente al 46,8%; p = 0,18), aunque numéricamente menor en los SM con trombosis muy tardía (el 26,6 frente al 48,0%; p = 0,07). La infraexpansión se

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observó de manera similar en ambos grupos (el 13,5 frente al 11,3%; p = 0,47). La neoateroesclerosis solo se observó en TS muy tardías y fue más prevalente en los SM (22,9%) que en los SFA (6,0%; p = 0,02). A los 2,9 años de seguimiento, las muertes cardiacas eran 0 frente a 6,9% respectivamente (p = 0,06) y las recurrencias de TS se produjeron en el 4,0 frente al 5,2% (p = 0,60).

Conclusiones: La malaposición es el hallazgo más frecuente en los pacientes con TS tardía y muy tardía, más prevalente en los SFA con TS muy tardías. Sin embargo, la neoateroesclerosis se observó únicamente en pacientes con TS muy tardías, y principalmente en SM.

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Abbreviations

BMS: bare-metal stent
DES: drug-eluting stent
IVUS: intravascular ultrasound
PCI: percutaneous coronary intervention
ST: stent thrombosis

INTRODUCTION

Stent thrombosis (ST) is a rare but life-threatening complication that usually results in ST-segment elevation myocardial infarction. The mortality rate is around 20% to 40%.[1,2] Definite late and very late ST are defined as the presence of angiographic or pathologic intrastent thrombus occurring later than 1 month after the index percutaneous coronary intervention (PCI).[3] The incidence of ST has been reduced in the last few years by the emergence of new-generation drug-eluting stents (DES) and contemporary antithrombotic therapies.[4–6]

The etiology of ST is usually multifactorial.[7] Intravascular ultrasound (IVUS) is an intracoronary imaging tool able to characterize vessel wall remodeling and to discern most causes of ST, such as persistent or late incomplete stent/strut apposition (malapposition), underexpansion, and neoatherosclerosis. Intravascular ultrasound can also predict cardiovascular events at follow-up in patients treated with IVUS-guided PCI.[8] Current myocardial revascularization guidelines recommend the use of intravascular imaging techniques to detect stent-related mechanical problems (class IIa, level of evidence C).[9] Assessment of causes of ST may help to select the best treatment strategy for each case. Treatment with balloon angioplasty without additional stent implantation has been associated with greater resolution of malapposition and stent underexpansion than treatment with additional stent implantation in the assessment of the posttreatment results with IVUS. In contrast, patients with neoatherosclerosis could benefit from additional stent implantation.[10]

Little is known about differences in the prevalence, timing, and causes of late and very late ST between bare-metal stent (BMS) and DES. The aim of this study was to compare the clinical, angiographic, and IVUS findings between BMS or DES in patients with definite late and very late ST.

METHODS

Population and Procedure Characteristics

All patients with angiographic late or very late ST (≥ 1 month) were prospectively included in 7 Spanish Institutions from January 2008 to December 2012. Late ST are those occurring between 31 days to 1 year after stent implantation, whereas very late ST are those occurring > 1 year after stent implantation.[3] All Institutions participating in the study were high-volume centers (> 500 PCI/y) with high use of IVUS for complex PCI.[11] A total of 250 consecutive

eligible patients presented with definite late or very late ST as defined by the Academic Research Consortium (0.69% of all PCIs performed by all institutions participating in the study). Of these, 117 lesions in 116 patients were imaged with IVUS. Three of these patients were excluded from the analysis due to lack of information on the stent type. The patient flowchart is shown in Figure 1. Most of the excluded patients were those seeking medical attention during off-office hours or were hemodynamically unstable. This study was approved by the local ethics committee of all participating institutions and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients.
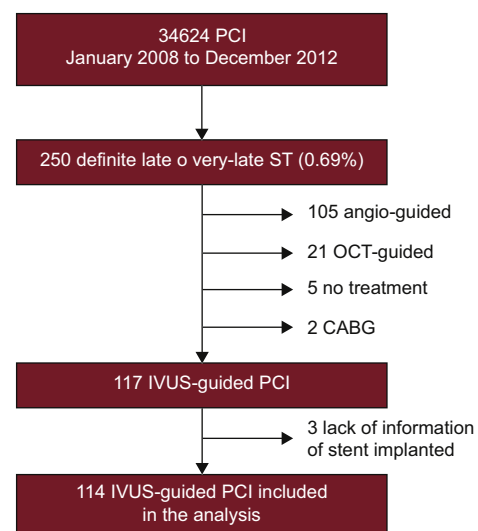
Percutaneous coronary intervention was performed according to the standard practices in each participating center and the treatment of the ST was left to the operator's discretion after "on-line" evaluation of IVUS images.

Intravascular Ultrasound Acquisition and Analysis

IVUS imaging was performed after the restoration of Thrombolysis in Myocardial Infarction (TIMI) flow ≥ 2 with thrombus aspiration or percutaneous transluminal coronary balloon angioplasty. IVUS acquisition was performed with the Atlantis 40 MHz catheter (Boston Scientific, Marlborough, MA, United States).

Image acquisition was done using an automated pullback system transducer with a pullback speed of 0.5 mm/s except for 1 institution that performed IVUS recording at 1 mm/s. The image data were digitally recorded for "off-line" analysis.

"Off-line" IVUS analysis was performed by 2 experienced analysts blinded to the type of stent implanted using quantitative IVUS analysis software (QIvus 3.0, Medis, Leiden, The Netherlands). All analyses were performed by a local core laboratory (BARCI-

Figure 1. Patient flowchart. CABG, coronary artery bypass graft; IVUS, intravascular ultrasound; OCT, optical coherence tomography; PCI, percutaneous coronary intervention; ST, stent thrombosis.