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Original article

Factors Associated With Errors in Visual Estimation of the Functional Significance of Coronary Lesions

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A B S T R A C T

Introduction and objectives: Visual angiographic assessment continues to be used when decisions are made on whether to revascularize ambiguous coronary lesions. Multiple factors, other than the degree of stenosis, have been associated with the functional significance of a coronary lesion. The aim of this study was to investigate the ability of interventionists to visually predict the functional significance of a coronary lesion and the clinical and angiographic characteristics associated with errors in prediction.
Methods: We conducted a concordance study of the functional significance of coronary lesions predicted by experienced interventionists and fractional flow reserve values measured by intracoronary pressure wire in 665 intermediate lesions (40%-70% diameter stenosis) in 587 patients. We determined which factors were independently associated with errors in prediction.
Results: There was disagreement between the predicted fractional flow reserve value of $\leq$ 0.80 and the observed value in 30.1% of the lesions (overestimation: 11.3%; underestimation, 18.8%). Stent location in an artery other than the anterior descending artery or in a bifurcation was associated with overestimation. Male sex, severe calcification, and a greater myocardial territory distal to the lesion were significantly associated with the functional significance of the underestimated lesion.
Conclusions: Even when taking into account angiographic and clinical characteristics, there is a high rate of disagreement between visual estimation and direct measurement of intermediate coronary stenosis in relation to its functional significance. Specific angiographic and clinical characteristics are associated with an increased tendency to overestimate or underestimate the significance of lesions.

Factores asociados al error en la estimación visual de la importancia funcional de lesiones coronarias

Palabras clave:
Enfermedad coronaria
Angiografía coronaria
Angioplastia coronaria
Reserva fraccional de flujo

R E S U M E N

Introducción y objetivos: La valoración angiográfica visual sigue utilizándose para decidir la revascularización de lesiones coronarias dudosas. Múltiples factores, distintos del grado de estenosis, se han asociado con la repercusión funcional de una lesión coronaria. El objetivo de este estudio es analizar la capacidad de predecir visualmente la repercusión funcional de una lesión coronaria y los condicionantes clínicos y angiográficos asociados con el error en la predicción.
Métodos: Estudio de concordancia entre la predicción de repercusión funcional realizada por intervencionistas expertos y el valor de reserva fraccional de flujo obtenido mediante guía intracoronaria de presión en 665 lesiones intermedias (estenosis del 40–70% del diámetro) en 587 pacientes. Se determinaron los factores independientemente asociados a un error en la predicción.
Resultados: Se observó una discordancia del 30,1% (sobrestimación, 11,3%; subestimación, 18,8%) entre el valor de reserva fraccional de flujo predicho $\leq$ 0,80 y el observado. La localización en el *stent*, en una arteria distinta de la descendente anterior y en una bifurcación se asoció a sobrestimación. El sexo masculino, la calcificación grave y el mayor territorio miocárdico distal a la lesión se asociaron significativamente con importancia funcional de la lesión subestimada.
Conclusiones: Incluso integrando características angiográficas y clínicas, la estimación visual de la importancia funcional de estenosis coronarias intermedias se asocia a una alta tasa de discrepancias respecto a su determinación real. Determinadas características angiográficas y clínicas se asocian específicamente con mayor tendencia a sobrestimar o subestimar la importancia de la lesión.

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Abbreviations

FFR: fractional flow reserve

INTRODUCTION

Although the main purpose of coronary revascularization is to treat myocardial ischemia, the degree of angiographic stenosis is used as the main parameter to guide decisions on whether to revascularize a lesion[1–3] or to determine the presence of restenosis after treatment. The significance of a coronary lesion is classically defined by the degree of angiographic stenosis, which is obtained by dividing the minimal lumen diameter by the reference diameter in the projection showing the greatest stenosis.[4,5] Invasive measurement of fractional flow reserve (FFR) has recently become established as the method of choice to determine the functional significance of coronary lesions, especially when their potential to produce ischemia is ambiguous.[4,5] Several studies have shown the limitations of angiography to define the functional significance of a lesion.[6–9] These limitations may be due to the difficulty of determining the true degree of stenosis in the presence of certain angiographic characteristics (curvature, calcification, bifurcations, ostial location, etc); another factor is that the functional significance of a lesion is determined by other factors that add to the degree of stenosis. The FFR across a specific lesion is affected, among others factors, by the size of the myocardial territory perfused by the vessel with the lesion,[10] lesion length,[11,12] the presence of collateral vessels,[13,14] diffuse disease of the distal bed, or the state of the microcirculation.[15,16]

Although several studies have found poor correlations between the functional significance of a lesion obtained by visual assessment and by FFR,[6–9,17] few studies have analyzed the factors associated with this discrepancy. The aim of the present study was to investigate the clinical and angiographic variables that could be associated with a greater degree of error when the functional significance of a coronary lesion is assessed by angiography.

METHODS

Design and Study Patients

We conducted a retrospective observational study of a historic cohort of patients referred to a cardiac catheterization laboratory for coronary angiography for suspected coronary disease between January 1, 2008 and May 31, 2012. The patients were evaluated for revascularization by measuring the FFR across an intermediate coronary lesion (40%-70% diameter stenosis by visual estimation) using a pressure wire. We excluded patients with lesions > 20% in a segment distal or proximal to the target lesion. The FFR was not measured in vessels that perfused akinetic or previously infarcted territory. In patients with acute coronary syndrome, the FFR was only measured in nonculprit vessels.

Procedure

All procedures were performed according to the usual protocol of the center conducting the study. After the decision was made to measure the FFR, the diagnostic catheter used for angiography was replaced by a 6-Fr guide catheter. This catheter was used to repeat the projections providing the best visualization of the lesions, with greater visual stenosis and without overlapping branches or loss of length because of curvature. All patients received 100 IU/kg intravenous sodium heparin before the procedure if not previously administered. Functional evaluation was performed with a 0.014-inch intracoronary pressure wire (Pressure Wire, Certus or Airis, Radi Medical Systems; Uppsala, Sweden, or Prime-Wire Prestige Pressure Guide Wire, Volcano Corp.; San Diego, California, United States). The pressure wire was calibrated externally and then advanced to the distal end of the guide catheter while equalizing the pressures according to the system used to measure the FFR. After administration of 200 μg to 300 μg intracoronary nitroglycerin, the guide was advanced until the sensor was at least 20 mm distal to the lesion. We followed the standard procedure used in our hospital to obtain the FFR by administering 300 μg to 1200 μg intracoronary adenosine, while taking particular care to avoid wedging the catheter in the coronary ostium after bolus injection of the drug. The beat-to-beat ratio of the mean aortic pressure at the end of the guide catheter and the pressure distal to the lesion, obtained via the pressure wire under maximum hyperemia, were used to measure the FFR. We measured the FFR at least 3 times and used the lowest measurement. We successively administered 300 μg, 600 μg and 1200 μg intracoronary adenosine whenever the previous dose failed to produce a period of asystole ≥ 6 s.

The decision to revascularize was left to the operator's discretion based on the data obtained in the angiographic and functional study.

Angiographic Variables

In our hospital, the routine method to obtain the FFR includes obtaining at least 1 projection that provides the best visualization of the lesion using the guide catheter, after the administration of intracoronary nitroglycerin. The diagnostic angiographic sequences of each procedure were separated from those obtained during the intervention (when applicable). The observers were only provided with diagnostic images and were blinded to the result of the FFR study when performing the digital quantification of lesion stenosis. Data were collected on the following variables: severe calcification (multiple opacification visible in more than 1 projection covering the entire vessel lumen at the site of the lesion); bifurcation (presence of a > 15-mm side branch originating at the site of the lesion); angulation > 45° (target lesion in a segment with angulation > 45°); ostial location (lesion at the origin of the vessel in the aorta); perfused myocardial territory (Duke jeopardy score[18,19]); and location of the lesion in the stent.

Digital quantification was performed using the QAngio XA version 7.1.43.0 postprocessing software package (Medis Medical Imaging Systems; Leiden, The Netherlands).

The lesions were analyzed by 2 experienced interventional cardiologists (more than 1000 coronary interventions using a pressure wire/measuring the FRR). One of them analyzed the lesions twice (OBS1A and OBS1B, with a 4-month interval between assessments), and the other analyzed them once (OBS2). They predicted whether the result of the pressure wire study was positive (FFR ≤ 0.80). The 2 observers were blinded to the previous predictions, the assessments made by the other, and the FFR results.

Based on their previous experience and published scientific evidence, the 2 observers took into account not only the degree of stenosis when making their predictions but also other parameters that have been associated with the FFR.[16] In cases of disagreement, the mode of the 3 predictions was used. Overestimation was defined by a predicted FFR ≤ 0.80 vs a measured FFR > 0.80. Underestimation was defined by a predicted FFR > 0.80