Comparison of Coronary calcifications detection by angiogram versus intravascular ultrasound

Habib Ben Ahmed, Khaled Bouzouita, Hamdi Imen, Aida Mokaddem, Youssef Ben Ameur, Mohamed Rachid Boujnah

Department of Cardiology, Mongi Slim Hospital, Tunis, Tunisia
Tunis Medical School, Tunis El Manar University

H. Ben Ahmed, K. Bouzouita, H. Imen, A. Mokaddem, Y. Ben Ameur, M. R. Boujnah

Comparaison entre la coronarographie et l'échographie endocoronaire dans la détection des calcifications coronaires

LA TUNISIE MEDICALE - 2013 ; Vol 91 (n°03) : 196-199

H. Ben Ahmed, K. Bouzouita, H. Imen, A. Mokaddem, Y. Ben Ameur, M. R. Boujnah

Comparison of Coronary calcifications detection by angiogram versus intravascular ultrasound

LA TUNISIE MEDICALE - 2013 ; Vol 91 (n°03) : 196-199

RÉSUMÉ

Prérequis : La présence, l'extension et la localisation des calcifications coronaires sont des déterminants majeurs du succès de l'angioplastie coronaire. La coronarographie demeure l'examen de référence pour le diagnostic de la maladie coronaire, mais actuellement l'échographie endocoronaire, technique d'introduction récente en Tunisie, s'impose comme étant plus performante dans la détection des lésions calcifiées.

But : Evaluer la sensibilité et la spécificité de la coronarographie dans la détection des calcifications en comparaison à l'échographie endocoronaire.

Méthodes : La présence de calcifications au niveau des lésions cibles a été analysée chez 40 patients (35 hommes, âge moyen 57.4 ± 10 ans) par coronarographie et par échographie endocoronaire.

Résultats : L'échographie endocoronaire a permis de détecter les calcifications dans 51 lésions cibles parmi 85 (60%), tandis que seulement 16 lésions calcifiées ont été identifiées à la coronarographie (19% p<0.001). La coronarographie a permis de visualiser les calcifications dans 8% des cas quand l'arc calcique au niveau de la lésion cible était compris entre 0 et 45°, 7% en cas d'arc calcique de 45-90°, 58% si la calcification formait un arc de 90-180°, et 80% des lésions quand il dépassait 180°.

Conclusion : L'échographie endocoronaire montre que les calcifications sont plus fréquentes et plus étendues que celles visualisées à la coronarographie. En dépit d'une haute spécificité pour reconnaitre les calcifications, la sensibilité de la coronarographie est très faible.

Mots-clés

Maladie coronaire, calcification, échographie endocoronaire, coronarographie

SUMMARY

Background: The presence, extent and location of calcium in coronary artery lesions are important determinants of the success of per cutaneous coronary intervention (PCI). Although coronarography remains the gold standard for coronary disease detection, Intravascular ultrasound (IVUS) is proposed as a superior technique for identifying patients with coronary artery calcification .

Aim: To define sensibility and specificity of coronary angiography in detecting calcifications considering the IVUS as gold standard.

Methods: Target lesion calcification was assessed in 40 patients (35 men; mean age 57.4 ± 10 years) by angiography and intravascular ultrasound.

Results: Ultrasound detected calcium in 51 of 85 target lesion (60%), whereas angiography showed calcifications in only 16 lesion (19% p<0.001 compared with IVUS). Coronary angiography detected 8% of 0-45° arc calcium category, 7% of 45-90° calcium category, 58% of 90-180° calcium category, and 80% of more than 180° calcium category. The overall sensitivity of angiography in identifying calcium was 31% and increased with an increasing arc of lesion-associated calcium. The overall specificity of the angiographic detection of target lesion calcium was 100%.

Conclusion : Intra coronary ultrasound analysis shows that target lesion calcification is much more widespread in coronary artery disease than what angiography reveals. The sensitivity of angiography was poor, with although a very high specificity.

Key-words

Coronary disease, calcification, Intra vascular ultrasound, coronary angiography

Selective coronary angiography has many limitations in guiding coronary revascularization, These limitations consist essentially on its inability to provide precise vascular dimensions, to assess plaque composition, and to detect and localize target lesion calcium (1, 2). Target lesion calcium is both a marker for significant coronary artery disease and a major determinant of the success of per cutaneous coronary interventions (3, 4). Intravascular ultrasound (IVUS) is based on slice imaging providing an exhaustive view of the arterial wall. Thus, the atherosclerotic plaque, and the changes that occur during the atherosclerotic disease process, and calcification spreading can be studied in vivo.

The purpose of this study is to compare detection of calcifications by angiogram and IVUS, to compare the calcification spreading in a lesion with its visibility by angiogram, and to define sensibility and specificity of angiogram in detecting calcifications considering the IVUS as gold standard.

METHODS

We prospectively studied 85 target lesions in 40 patients by IVUS and coronary angiography from March 2009 to November 2011. These lesions met the following criteria:

- Native vessel location lesion.
- Intermediate or ambiguous lesion.

There were 35 men and 5 women, with median age of 57.4±10 years . Target lesion location was left main in 13, left anterior descending in 46, left circumflex in 15, and right coronary artery in 11.

IVUS Analysis

IVUS studies used Atlantis SR Pro Catheter (Boston scientific), which incorporates a single-element 40-MHz transducer and provide planar cross-sectional images in real time; with this system, the transducer was withdrawn automatically at 0.5 mm/s to perform the imaging sequence. IVUS studies were recorded on external hard disk for off-line analysis.

Quantitative analysis of the ultrasound images was performed by a single individual blinded to the angiographic results. A number of cross-sectional measurements were made, including lesion lumen area, plaque-plus-media cross-sectional areas and maximum and minimum diameters (5, 6).

Plaque composition was assessed visually to identify lesion calcium (7, 8). Calcium produced bright echoes (brighter than the reference adventitia) with acoustic shadowing of deeper arterial structures (Figure 1). The extent and distribution of target lesion calcification was assessed as follows:

The largest arc(s) of target lesion calcium were measured in degrees with a protractor centered on the lumen. Calcification was then classified as none, between 0° and 45°, between 45° and 90°, between 90° and 180°, and more than 180° calcification (Figure 2).

Angiographic Analysis

Pre procedural angiograms were reviewed by an operator who was blinded to the ultrasound results. Calcification was identified as readily apparent radiopacities within the vascular wall at the site of the stenosis. Quantitative angiographic analysis used a computer-assisted, automated edge-detection algorithm (GE QCA, Centricity AI 1000 – GE Mnet Version 4.1.15.07). With the external diameter of the contrast-filled catheters as the calibration standard, the minimal lumen diameter at end diastole before intervention was measured from orthogonal projections, and the results from the "worst" view were recorded.

Figure 1: Calcified lesion showed as a bright echoes with acoustic shadowing

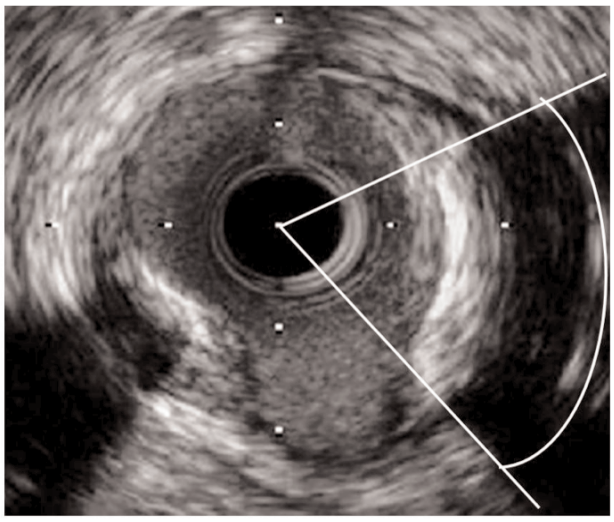
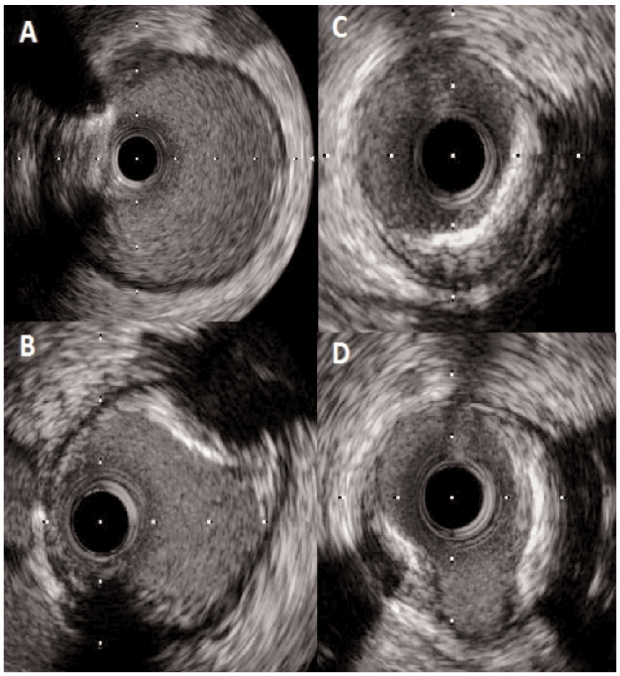


Figure 2: Four examples of intravascular ultrasound target lesion calcium. A, Arc of target lesion calcium between 0 and 45°. B, Arc of target lesion calcium between 45 and 90°. C, Arc of target lesion calcium between 90 and 180°. D, Arc of target lesion calcium of more than 180°.



Statistics

Statistical analysis was performed with PASW® statistics version 18 (SPSS inc., Chicago, Illinois, USA) Quantitative data are presented as mean ± SD. Qualitative data are presented as frequencies. Categorical variables were assessed by □2 statistics. Continuous variables were compared by unpaired Student's t tests and ANOVA as appropriate.

RESULTS

IVUS Target Lesion Calcium

By IVUS, 51 of 85 target lesions (60%) contained calcium. The mean length of target lesion calcium measured 10.9 ± 6.7 mm. The frequency distribution of the arcs and lengths of target lesion calcium is shown in Figures 3 and 4.

Figure 3: Frequency distribution of the maximum arc of intravascular ultrasound target lesion calcium. Coronary angiography detected 8% of 0-45° calcium category, 7% of 45-90° calcium category, 58% of 90-180° calcium category, and 80% of more than 180° calcium category. The sensitivity of angiography increased with an increasing arc of lesion-associated calcium (P<.0001).

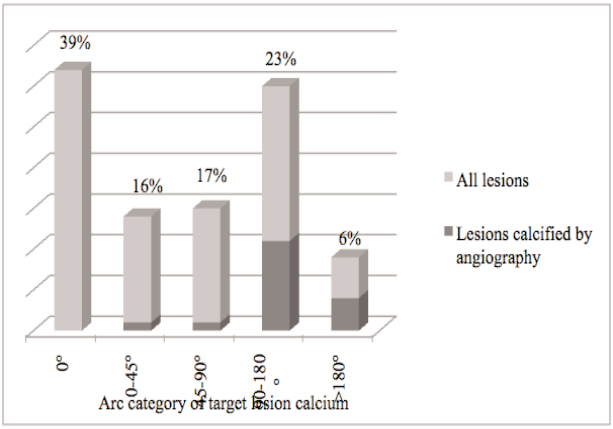
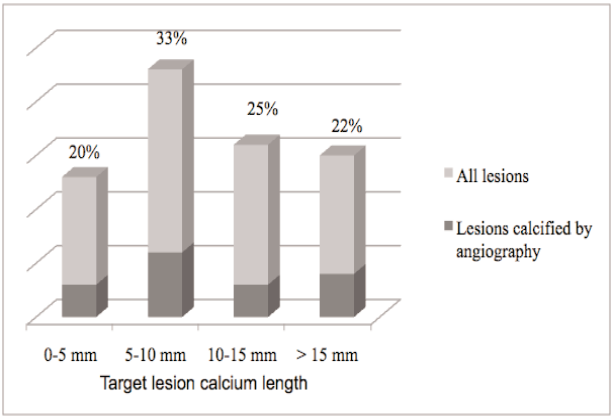


Figure 4: Frequency distribution of the lengths of intravascular ultrasound target lesion calcium. Coronary angiography detected 30% of calcium ≤5 mm in length, 35% of calcium 5 to 10 mm in length, and 23% of calcium 10 to 15 mm in length, and 36% of calcium > 15 mm in length. The sensitivity of angiography did not increase with an increasing length of lesion-associated calcium.



Angiographic Results

The mean reference segment diameter measured 3.2±0.8 mm, the mean minimum lumen diameter measured 1.7±0.5 mm, and the mean percent diameter stenosis measured 44.1±12.7%.

Coronary angiography detected target lesion calcium in 16 of 85 lesions (19%, P<.0001 compared with IVUS). The presence of angiographic calcium correlated with an increasing arc of IVUS target lesion calcium (Figure 2).

The overall sensitivity of angiography in detecting the presence of target lesion calcium was 31%; it was lowest in those lesions with less than 90° calcium, 62% in those with more than 90°, and highest (80%) in lesions with more than 180° calcium. The overall specificity of the angiographic detection of target lesion calcium was 100%. We didn't note any false positive calcification by angiography in these 85 target lesions.

DISCUSSION

This study demonstrated that angiography is an inadequate technique in the evaluation of calcium. Indeed, angiography detected calcifications in only 19% of lesions, against 61% by IVUS.

Lesion associated coronary artery calcium is essentially associated with patient's age, dyslipidaemia, chronic hypercalcemia, and chronic renal insuffiency (9-12). It also reflects the extension and severity of atherosclerosis (13). Therefore, it is an important factor in assessing the complexity of a coronary lesion, and may influence the technique and the strategy of revascularization.

Intravascular ultrasound details the relationship between plaque and vessel wall in real time throughout the coronary arterial tree. This provides the opportunity to define not only the quantity but also the distribution of calcium within the vessel wall. The identification of calcifications can alert the operator to change PCI strategy. Rotational atherectomy or cutting balloon in such cases can provide significant de-calcification in preparation for optimal stenting.

These important differences between angiography and IVUS have been confirmed by several studies: Mintz et al. analyzed 1117 lesions by these two techniques (14). Lesion associated coronary artery calcium was detected in 38% of lesions on angiography against 73% of lesions with intravascular ultrasound, which is comparable to our results. Moreover, the distribution of angiographically detected calcium depending of calcium arc length measured by IVUS was similar to ours, showing a better detection of calcium by angiography for an arc exceeding 90° of calcium. However, this study showed that lesion length was significantly related with angiographically detected calcium target lesion. This result was not confirmed in our serie.

Another study of 1454 lesions analyzed the possible relationship between the reference diameter of a lesion and the presence of calcium detected by IVUS (15). Lesion associated related calcium was detected in 37% of lesions by angiography against 73% by IVUS. Moreover, a proportional relationship was found between the decrease in angiographic reference

diameter and the presence of calcium in IVUS undetected by the angiogram, especially for the arteries of less than 2 mm.
In our study, no lesions with angiographic reference diameter less than 2 mm were evaluated. However, we analyzed the size distribution of references for lesions that contained angiographically undetected calcium, we have not found a preponderance of small arteries. Indeed, 17 of the 35 lesions involved had a reference diameter of less than 3 mm. These studies confirm the limitations of angiography to identify and quantify lesion associated coronary artery calcium, confirming the results of our serie.
The overall measured accuracy of diagnosing target lesion calcium by angiography in this study was 31%. Although angiography's specificity to the presence of lesion calcium may be high, it was fairly insensitive in the presence less than 90° arc of calcium. These results are similar to Mintz's study cited above (14) in which IVUS detected target lesion calcium far more often than angiography, but that showed a greater accuracy than in our study.
Beside this advantage in detecting target lesion calcium, there still are limitations to its assessment. Thus, IVUS can only identify the leading edge of a calcific deposit, not its thickness. Similarly, IVUS cannot detect a deep calcification behind superficial calcium. Deep calcium may be hidden until the bulky superficial plaque is removed; and densely fibrotic noncalcified plaque may not be penetrated and cause shadowing to be confused with calcium. On IVUS imaging, all calcium appears the same way; however, not all calcium has the same physical properties (16), and thus the same response to a balloon expansion and stent apposition.

Study limitations

This serie represent the first study in Tunisia assessing coronary calcifications using IVUS, however it concerned few patients and a small number of lesions. Moreover in this study, IVUS provide only a bi dimensional vessel slice by which calcifications could be underestimated, a three dimensional IVUS reconstruction is an excellent alternative to analyze the real volume of calcified plaque.

CONCLUSION

Intra coronary ultrasound analysis shows that target lesion calcification is much more widespread in coronary artery disease than what angiography shows; the prevalence of calcium was 60%. Also, IVUS can assess the arc, length, and its distribution in the artery wall.
The sensitivity of angiography was poor 31%, with although a very high specificity. This technique is clearly insufficient to detect correctly target lesion calcification.

References

1. Mintz G, Douek P, Pichard A, et al. Target lesion calcification in coronary artery disease: an intravascular ultrasound study. J Am Coll Cardiol. 1992;20:1149-55.
2. The GUIDE Trial Investigators. Initial report of the `GUIDE' Trial for intravascular ultrasound imaging in coronary interventions. J Am Coll Cardiol. 1992;19:223A.
3. Detrano R, Wong N, French W, et al. Prevalence of fluoroscopic coronary calcific deposits in high-risk asymptomatic persons. Am Heart J. 1994;127:1526-32.
4. Fallavollita J, Brody A, Bunnell I, Kumar K, Canty JJ. Fast computed tomography detection of coronary calcification in the diagnosis of coronary artery disease in patients <50 years old. Circulation. 1994;89: 285-90.
5. Pandian N, Kreis A, Brockway B, et al. Ultrasound angioscopy: real-time, two-dimensional, intraluminal ultrasound imaging of blood vessels. Am J Cardiol. 1988;62:493-94.
6. Hodgson JM, Graham SP, Sarakus AD, et al. Clinical percutaneous imaging of coronary anatomy using an over-the-wire ultrasound catheter system. Int J Card Imaging. 1989;4:186-93.
7. Nishimura R, Edwards W, Warnes C, et al. Intravascular ultrasound imaging: in vitro validation and pathologic correlation. J Am Coll Cardiol. 1990;16:145-54.
8. Hodgson J, Reddy K, Suneja R, Nair R, Lesnefsky E, Sheehan H. Intracoronary ultrasound imaging: correlation of plaque morphology with angiography, clinical syndrome and procedural results in patients undergoing coronary angioplasty. J Am Coll Cardiol. 1993;21:35-44.
9. Gertz S, Malekzadeh S, Dollar A, Kragel A, Roberts W. Composition of atherosclerotic plaques in the four major epicardial coronary arteries in patients ≥90 years of age. Am J Cardiol. 1991;67:1228-33.
10. Roberts W, Waller B. Effect of chronic hypercalcemia on the heart. Am J Med. 1981;71:371-84.
11. Dinsmore R, Lees R. Vascular calcification in types II and IV hypercholesterolemia: radiographic appearance and clinical significance. Am J Roentgenol. 1985;144:895-99.
12. Meema H, Oreopoulos D, deVeber G. Arterial calcifications in severe chronic renal disease and their relationship to dialysis treatment, renal transplant, and parathyroidectomy. Radiology. 1976;121:315-21.
13. Masuda Y, Naito S, Ayagi Y, et al. Coronary artery calcification detected by CT: clinical significance and angiographic correlates. Angiology. 1990;41:1037-47.
14. Mintz GS, Popma JJ, Pichard AD, et al. Patterns of calcification in coronary artery disease, a statistical analysis of intravascular ultrasound and angiography in 1155 lesions. Circulation 1995;91:1959-65.
15. Mintz GS, Pichard AD, Kent AM, et al. Interrelation of coronary angiographic reference lumen size and intravascular ultrasound target lesion calcium. J Invasive Cardiol 2007;19:412-16.
16. Foreman DW, Mitchell JC, Baker PB. Physical chemical evidence of structural weakness in coronary arterial calcification. Cardiovasc Res. 1989;23:64-9.