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Letter to the Editor

# Analysis of residual thrombotic burden after thrombus aspiration in acute ST elevation myocardial infarction: An optical coherence tomographic evaluation

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Thrombus remains a limiting factor for achieving percutaneous coronary intervention (PCI) success during acute coronary syndrome, as it increases procedural complications (including distal embolization, no-reflow or stent malapposition) [1,2]. Thromboaspiration (TA) techniques can improve these results by reducing thrombus load within the culprit lesion, but its actual efficiency on thrombus volume remains unknown and the real benefits of the technique are debated [3]. Moreover, the angiographic assessment of residual thrombotic burden following TA is suspected to provide several inaccuracies. In this work, we assessed the feasibility of residual thrombotic burden quantification following TA by optical coherence tomography (OCT) in STEMI and its relation to angiographic parameters.

Patients with acute STEMI (symptoms onset ≤ 12 h) with initial TIMI 0 or 1 flow and high thrombotic burden (Thrombus TIMI grade ≥ 3) on culprit lesion and who benefited from successful mechanical thrombus aspiration (defined as TIMI flow ≥ 2 + chest pain cessation + ST elevation resolution > 50%) with no use of balloon predilation were screened for inclusion. Our local Ethics Committee approved the study and informed consent was obtained for each patient.

All procedures were performed through radial access. Patients were treated in accordance with the European Society of Cardiology (ESC) guidelines for management of patients with STEMI [4]. PCI was performed with a 6 Fr guiding catheter in all patients. Thrombo-aspiration was performed using a manual thrombectomy device (Eliminate. TERUMO, Tokyo, Japan). The number of passes was left at the operator discretion, in order to obtain optimal flow and satisfactory angiographic result.

Culprit lesion OCT analysis was performed following TA in patients with successful procedure with a commercially available system (C7 System; LightLab Imaging Inc./St Jude Medical, Westford, MA).

Two operators retrospectively reviewed coronary angiography and analyzed pre and post-thrombectomy culprit lesion characteristics, including antegrade angiographic flow, thrombus grade according to the TIMI criteria as well as the percentage of stenosis (before and after thrombectomy) by quantitative coronary angiography.

FD-OCT image analysis methods have been extensively described elsewhere [5]. Briefly, thrombi were defined as masses protruding into the vessel lumen, discontinuous from the surface of the vessel wall and characterized according to the signal characteristics. The longitudinal view was used to mark and measure the length of the athero-thrombotic lesion. The outlines of lumen and thrombus were drawn for area measurements on cross-sectional images by multiple point trace function within the athero-thrombotic culprit lesion in 1 mm intervals, allowing calculations of the OCT-thrombus volume, OCT-thrombus score and area stenosis. Proximal and distal reference lumen areas, as well as minimal lumen area (MLA) were measured for each lesion. References were defined as the most "normal-appearing" segments 5 mm proximal and distal to the lesion shoulders by OCT. The reference lumen area was the average of proximal and distal references lumen areas. Percent area stenosis was calculated as follows: 100 ∗ (reference lumen area − MLA) / reference lumen area.

Data are expressed as mean and standard error to the mean (SEM). Continuous and categorical variables were compared using the Student t-test and the chi-square test or Fisher's exact test. Univariate correlations were assessed by Pearson's correlation or Spearman's rho (ρ) test after log-transformation of variables.

From September 2011 to December 2012, N = 36 patients fulfilled the inclusion criteria. Three out of these subjects were excluded for inadequate image quality related to abundant red thrombus on initial analysis (inducing inability to accurately delimitate thrombus and lumen areas). Finally, n = 33 patients were included in the study. Baseline characteristics of the population are given in Table 1. Aspiration thrombotic debris was found in 91% of patients. OCT was feasible in all

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**Table 1**
Baseline characteristics of the population.

| Baseline characteristics (n = 33) | |
|---|---|
| Age (years) | 59.3 ± 2.8 |
| Male gender, n (%) | 26 (79) |
| Diabetes, n (%) | 4 (12) |
| Active smoking, n (%) | 15 (45) |
| Hypertension, n (%) | 16 (48) |
| Hypercholesterolemia, n (%) | 18 (55) |
| Body mass index ($kg \cdot m^{-2)}$) | 26.1 ± 0.5 |
| Symptoms onset to PCI delay (min) | 308 ± 51 |
| Culprit lesion localization | |
| Left anterior descending artery, n (%) | 16 (48) |
| Right coronary artery, n (%) | 13 (40) |
| Circumflex artery, n (%) | 4 (12) |
| Primary PCI, n (%) | 28 (85) |
| Initial TIMI flow | 0.7 ± 0.2 |
| Initial thrombus angiographic grade | 4.6 ± 0.2 |
| Initial culprit lesion QCA, n (%) | 91.0 ± 3.0 |
| TA number of passes | 2.8 ± 0.3 |
| Final TIMI flow | 2.8 ± 0.1 |
| Post TA thrombus angiographic grade | 2.6 ± 0.1 |
| Post TA culprit lesion QCA, n (%) | 66.2 ± 3.5 |
| OCT thrombus parameters | |
| Residual thrombus, n (%) | 100 |
| White thrombus, n (%) | 27 (82) |
| Red thrombus, n (%) | 6 (18) |
| Thrombus length (mm) | 9.0 ± 0.8 |
| OCT-thrombus score | 23.0 ± 3.2 |
| OCT-thrombus volume ($mm^2$) | 17.0 ± 4.0 |
| Minimal lumen area ($mm^2$) | 2.0 ± 0.3 |
| Post-TA culprit lesion area stenosis (%) | 74.6 ± 2.8 |

cases and did not induce any complication (including embolization, artery re-occlusion or patent dissection). Residual thrombotic material was present in all cases, irrespective of the angiographic result: the residual OCT-thrombus volume and OCT-thrombus score were respectively 17.0 ± 4.0 $mm^3$ and 23.0 ± 3.2. (See Table 2.)

OCT thrombus indices were correlated (Spearman's $\rho = 0.47$, $p = 0.02$) but did not correlate with any of the post-TA angiographic characteristics, including post-TA QCA (OCT thrombus volume: Spearman's $\rho = 0.19$, $p = 0.3$; OCT-thrombus score Spearman's $\rho = 0.2$, $p = 0.35$) and post-TA angiographic thrombus grade (OCT thrombus volume: Spearman's $\rho = 0.17$, $p = 0.38$; OCT-thrombus score Spearman's $\rho = 0.22$, $p = 0.28$). However, we observed a mild correlation between degrees of stenosis estimated by angiography (QCA) and by OCT (area derived percentage) (Spearman's $\rho = 0.44$, $p = 0.02$).

**Table 2**
Comparison between patients with post-TA culprit lesion QCA ≤ 70% vs. QCA > 70%.

| | Post-TA QCA ≤ 70% (n = 19) | Post-TA QCA > 70% (n = 14) | p |
|---|---|---|---|
| Age (years) | 60.4 ± 3.6 | 57.7 ± 4.5 | 0.64 |
| Male gender, n (%) | 15 (79) | 11 (79) | 0.7 |
| Diabetes, n (%) | 2 (11) | 2 (14) | 0.6 |
| Active smoking, n (%) | 10 (53) | 5 (36) | 0.33 |
| Hypertension, n (%) | 8 (42) | 8 (57) | 0.4 |
| Hypercholesterolemia, n (%) | 12 (63) | 6 (43) | 0.25 |
| Symptoms onset to PCI delay (min) | 237 ± 40 | 399 ± 101 | 0.15 |
| Initial TIMI flow | 0.8 ± 0.2 | 0.4 ± 0.2 | 0.16 |
| Initial culprit lesion QCA, n (%) | 86 ± 4.5 | 97.6 ± 2.1 | 0.03 |
| Initial thrombus angiographic grade | 4.5 ± 0.6 | 4.8 ± 0.4 | 0.16 |
| TA number of passes | 3.1 ± 0.4 | 2.4 ± 0.3 | 0.19 |
| Final TIMI flow | 2.9 ± 0.1 | 2.7 ± 0.2 | 0.33 |
| Post TA culprit lesion QCA, n (%) | 54.8 ± 4.1 | 81.7 ± 2.6 | <0.001 |
| Post TA thrombus angiographic grade | 2.1 ± 1.0 | 3.2 ± 0.8 | 0.002 |
| White Thrombus, n (%) | 17 (89) | 10 (71) | 0.36 |
| Thrombus length (mm) | 8.8 ± 1.0 | 9.2 ± 1.4 | 0.8 |
| OCT-thrombus score | 20.6 ± 2.6 | 26.5 ± 6.7 | 0.36 |
| OCT-thrombus volume ($mm^2$) | 15.5 ± 3.6 | 18.8 ± 8.2 | 0.69 |
| Minimal lumen area ($mm^2$) | 2.0 ± 0.3 | 1.7 ± 0.4 | 0.56 |
| Post TA culprit lesion area stenosis (%) | 72.6 ± 4 | 77.3 ± 3.9 | 0.42 |

Patients were divided into 2 groups according to the post-TA angiographic analysis: optimal (QCA ≤ 70%) and sub-optimal (QCA > 70%) result. We didn't observe any significant difference in the thrombus OCT characteristics between the two groups, suggesting that angiography and QCA accuracies for evaluation of thrombus burden in STEMI are limited.

This study is the first to our knowledge that used intra-coronary imaging OCT techniques to specifically investigate immediate results of TA in STEMI patients. Our results provide novel insights on this technique as they show that: 1) complete retrieval of thrombus can hardly be achieved with TA alone and 2) angiography is not an efficient tool to assess the procedural success.

These data are in line with previous observations in non ST- and STEMI patients treated by TA and PCI, in which OCT depicted the presence of residual thrombus within stent [6,7]. Altogether, these results indicate that manual thrombectomy might have a limited role to completely remove thrombus from the culprit lesion. In this perspective, our data suggest that a 2 steps-approach (initial thrombectomy followed by deferred stenting) could be proposed in some selected STEMI patients, with the presence of abundant thrombus following initial TA [8]. An optimal medical therapy (including anticoagulation + double anti-platelet therapy) should be provided between initial and subsequent PCI, allowing adequate thrombus regression [5]. Since angiography has a limited sensitivity to detect residual thrombus, OCT might thus represent a better option to guide this specific management option.

## Conflict of interest

Drs. Amabile and Caussin received consulting fees from St Jude Medical; the other authors reported nothing to disclose in relation with the present article.

## References

[1] M. Singh, P.B. Berger, H.H. Ting, C.S. Rihal, S.H. Wilson, R.J. Lennon, et al., Influence of coronary thrombus on outcome of percutaneous coronary angioplasty in the current era (the Mayo Clinic experience), Am. J. Cardiol. 88 (2001) 1091–1096.

[2] N. Gonzalo, P. Barlis, P.W. Serruys, H.M. Garcia-Garcia, Y. Onuma, J. Ligthart, et al., Incomplete stent apposition and delayed tissue coverage are more frequent in drug-eluting stents implanted during primary percutaneous coronary intervention for ST-segment elevation myocardial infarction than in drug-eluting stents implanted for stable/unstable angina: insights from optical coherence tomography, JACC Cardiovasc. Interv. 2 (2009) 445–452.

[3] O. Frobert, B. Lagerqvist, G.K. Olivecrona, E. Omerovic, T. Gudnason, M. Maeng, et al., Thrombus aspiration during ST-segment elevation myocardial infarction, N. Engl. J. Med. 369 (2013) 1587–1597.

[4] P.G. Steg, S.K. James, D. Atar, L.P. Badano, C.B. Lundqvist, M.A. Borger, et al., ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC), Eur. Heart J. 33 (2012) 2569–2619.

[5] N. Amabile, S. Hammas, S. Fradi, G. Souteyrand, A. Veugeois, L. Belle, P. Motreff, C. Caussin, Intra-coronary thrombus evolution during acute coronary syndrome: regression assessment by serial optical coherence tomography analyses, Eur. Heart J. Cardiovasc. Imaging (2014) (pii: jeu228, Epub ahead of print).

[6] M. Magro, E. Regar, J.L. Gutierrez-Chico, H. Garcia-Garcia, C. Simsek, C. Schultz, et al., Residual atherothrombotic material after stenting in acute myocardial infarction—an optical coherence tomographic evaluation, Int. J. Cardiol. 167 (2013) 656–663.

[7] W.G. Wieringa, C.P. Lexis, G.F. Diercks, E. Lipsic, E.S. Tan, R.A. Schurer, et al., The feasibility of optical coherence tomography guided thrombus aspiration in patients with non-ST-elevation myocardial infarction after initial conservative therapy — a pilot study, Int. J. Cardiol. 168 (2013) 4981–4982.

[8] X. Freixa, L. Belle, L. Joseph, J.-Fß. Tanguay, G. Souteyrand, P. L'Allier, et al., Immediate vs. delayed stenting in acute myocardial infarction: a systematic review and meta-analysis, EuroIntervention 8 (2013) 1207–1216.