

Case Report 

# First-in-Man Computed Tomography-Guided Percutaneous Revascularization of Coronary Chronic Total Occlusion Using a Wearable Computer: Proof of Concept

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## ABSTRACT

We report a case of successful computed tomography-guided percutaneous revascularization of a chronically occluded right coronary artery using a wearable, hands-free computer with a head-mounted display worn by interventional cardiologists in the catheterization laboratory. The projection of 3-dimensional computed tomographic reconstructions onto the screen of virtual reality glass allowed the operators to clearly visualize the distal coronary vessel, and verify the direction of the guide wire advancement relative to the course of the occluded vessel segment. This case provides proof of concept that wearable computers can improve operator comfort and procedure efficiency in interventional cardiology.

## RÉSUMÉ

Nous rapportons un cas de revascularisation réussie par voie percutanée guidée par tomodensitométrie de l'artère coronaire droite obstruée de manière chronique au moyen d'un ordinateur vestimentaire mains libres et visiocasque porté par les cardiologues interventionnels au laboratoire de cathétérisme. La projection des reconstructions 3D par tomodensitométrie sur l'écran des lunettes de réalité virtuelle permettait aux opérateurs de visualiser clairement le segment distal du vaisseau coronaire et de vérifier le sens de la progression du fil-guide par rapport à la trajectoire du segment obstrué du vaisseau. Le présent cas fournit la preuve du concept qui soutient que les ordinateurs vestimentaires peuvent améliorer le confort de l'opérateur et l'efficacité des actes en cardiologie interventionnelle.

Coronary computed tomography angiography (CTA) is uniquely suited to provide guidance during percutaneous coronary intervention (PCI) in chronic total occlusion.<sup>1</sup> Specifically, the occluded coronary segment and the distal vessel territory are often more clearly depicted on coronary CTA than in invasive angiography.<sup>1,2</sup> Of particular interest, the procedure itself might be facilitated by projection of 3-dimensional CTA data sets in the catheterization laboratory,<sup>3</sup> but this technique is limited by economic and technical factors.<sup>1</sup>

## Case Report

A 49-year-old hypertensive man with a history of coronary artery bypass grafting and PCI of the left circumflex

artery presented with persisting Canadian Cardiovascular Society class III angina. Cardiac magnetic resonance imaging showed a preserved left ventricular ejection fraction and extensive reversible perfusion defect in the right coronary artery (RCA) territory. Coronary angiography showed a patent stent in the left circumflex artery, patent left internal mammary artery graft to the left anterior descending coronary artery, and a medial chronic occlusion of the RCA with incomplete filling of the distal coronary vessel (Fig. 1, Video 1 ; view video online). In contrast to invasive angiography, coronary CTA, performed using a dual-source Somatom Definition Flash scanner (Siemens, Erlangen, Germany), revealed a complete course of the distal RCA with severe calcification proximal to the occlusion site (Supplemental Fig. S1).

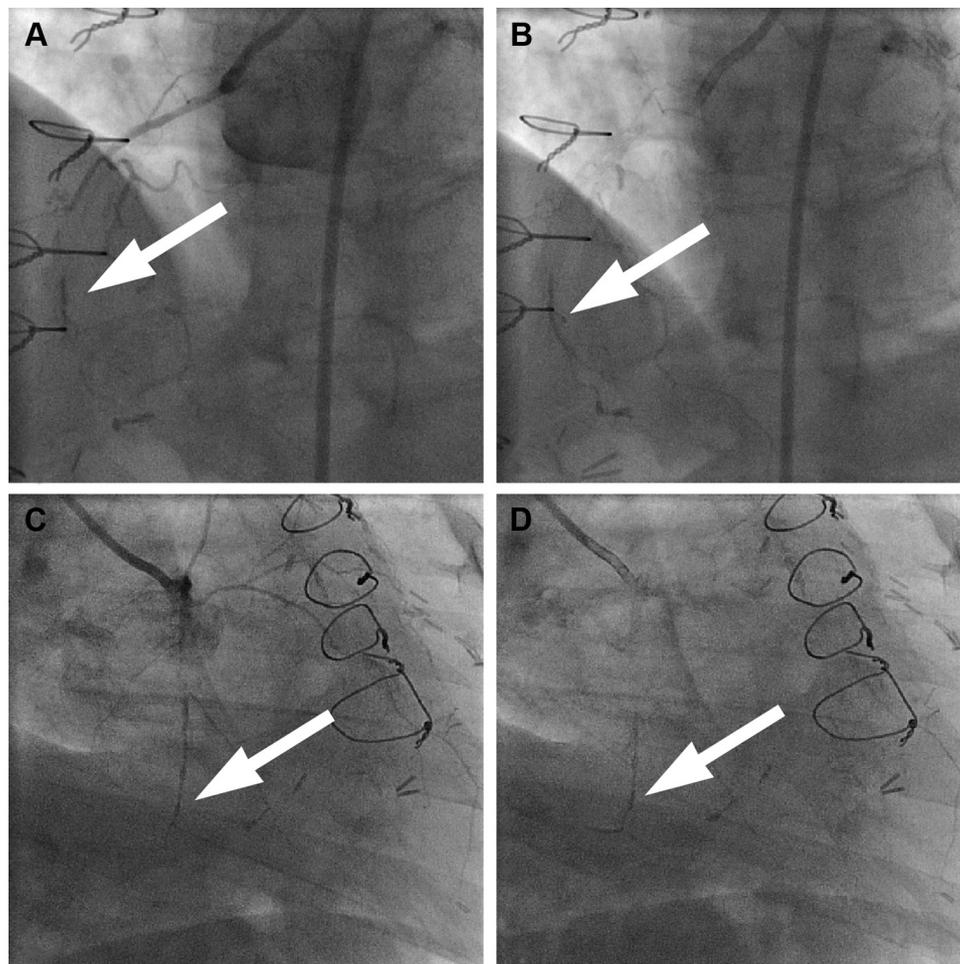
Three-dimensional, static CTA reconstructions of the RCA corresponding to the angulations of the C-arm without foreshortening were selected using the syngo.via software (Siemens Healthcare, Erlangen, Germany), and subsequently transmitted to Google Glass (Google Inc, Mountain View, CA) for display in a mobile application equipped with a hands-free voice recognition system and a zoom function

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See page 1.e2 for disclosure information.



**Figure 1.** Images of coronary angiography. (A, B) Early and late frames of the cine sequence in the left anterior oblique projection with incomplete visualization of the distal RCA (arrows). (C, D) Early and late frames of the cine sequence in the right anterior oblique projection with incomplete visualization of the distal RCA (arrows). RCA, right coronary artery.

developed specifically for this purpose (Fig. 2). In addition, a video of the CTA data sets was displayed for review on Google Glass (Video 2 [\[E\]](#); view video online).

RCA recanalization was attempted on the basis of CTA projections in Google Glass allowing the operators to clearly visualize the distal coronary vessel, and verify the direction of the guide wire advancement relative to the course of the occluded vessel segment. PCI was successful with implantation of 2 drug-eluting stents in the proximal to distal RCA segments and Thrombolysis In Myocardial Infarction flow grade 3 (Supplemental Fig. S2).

## Discussion

Recently, the concept of wearable computers such as Google Glass has been receiving increased attention of the medical community, and physicians from different specialties are beginning to incorporate this technology into their practice.<sup>4</sup> Google Glass is a device with an optical head-mounted display that possesses the ability to display and capture images and videos while interacting with the surrounding environment. This display is an example of the concept of virtual reality in which the user is supplemented with additional information generated by the device.

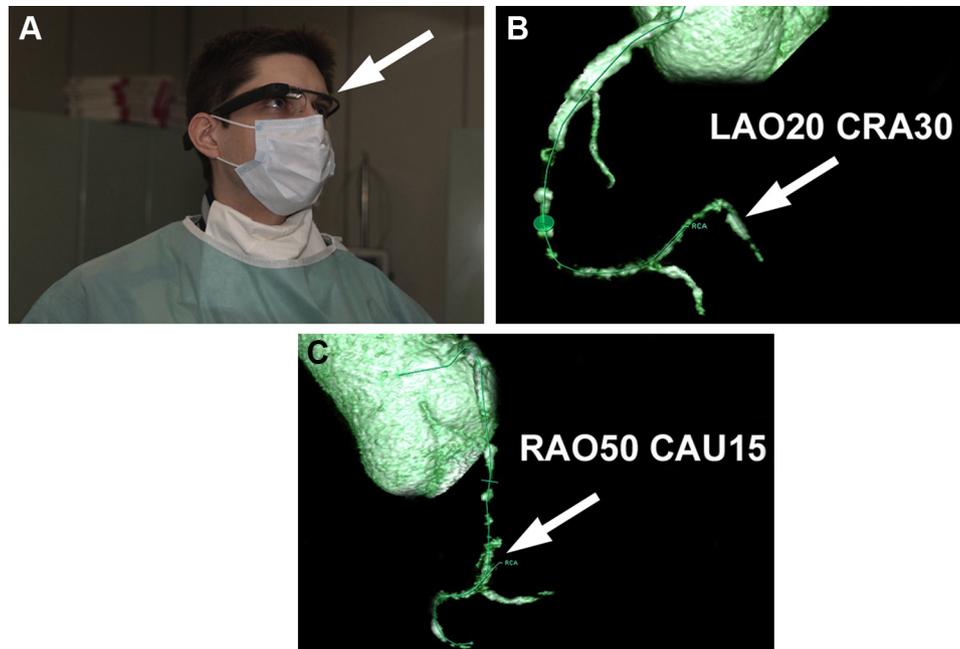
This case demonstrates the novel application of wearable computers for display of CTA data sets in the catheterization laboratory that can be used for better planning and guidance of interventional procedures. Of particular interest, mobile technology is easily accessible and offers an incremental opportunity to expand the existing open platform for mobile applications, which might in turn overcome the economic and capacity limitations of most advanced angiography systems with dedicated monitors for projection of CTA data sets. Furthermore, wearable devices such as Google Glass might be potentially equipped with filter lenses that provide protection against X-radiation. We believe wearable computers have a great potential to optimize percutaneous revascularization, and thus favourably affect interventional cardiologists in their daily clinical activities.

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## Disclosures

The authors have no conflicts of interest to disclose.



**Figure 2.** CTA images displayed in Google Glass. **(A)** Cardiologist viewing the CTA images in the upper right visual field on Google Glass (Google Inc, Mountain View, CA) (**arrow**) during a CTO recanalization attempt. **(B, C)** Three-dimensional reconstructions projected directly onto the Google Glass screen reveal the exact trajectory of the distal RCA (**arrows**). CTA, computed tomography angiography; CTO, chronic total occlusion; RCA, right coronary artery.

## References

1. Opolski MP, Achenbach S. Coronary computed tomography angiography for revascularization of chronic total occlusions—crossing the borders of diagnosis and treatment. *JACC Cardiovasc Imaging* 2015;8: 846-58.
2. Opolski MP, Achenbach S, Schuhbäck A, et al. Coronary computed tomographic prediction rule for time-efficient guidewire crossing through chronic total occlusion: insights from the CT-RECTOR multicenter registry (Computed Tomography Registry of Chronic Total Occlusion Revascularization). *JACC Cardiovasc Interv* 2015;8: 257-67.
3. Rolf A, Werner GS, Schuhbäck A, et al. Preprocedural coronary CT angiography significantly improves success rates of PCI for chronic total occlusion. *Int J Cardiovasc Imaging* 2013;29:1819-27.
4. Glauser W. Doctors among early adopters of Google Glass. *CMAJ* 2013;185:1385.

## Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Cardiology* at [www.onlinecjc.ca](http://www.onlinecjc.ca) and at <http://dx.doi.org/10.1016/j.cjca.2015.08.009>.