

Background information

Clinical Challenges

Stationary multiple coronary angiography views is a widely used standard acquisition method for diagnosis and evaluation of coronary artery disease with several accepted known diagnostic accuracy limitations, especially of intermediate severity lesion and particularly in the presence of complex or eccentric lesions. The acquisition usually consists of 6–10 separate acquisitions or runs each requiring 5–10 cc of contrast to capture these multiple stationary views of the coronary arteries. Considerable amount of contrast medium and radiation exposure are used to obtain these standard views as well.

The goal a coronary angiogram is to obtain as much information required for lesion assessment with minimal vessel foreshortening. At the same time without losing any of the required information and views, minimizing contrast volume and radiation exposure to reduce the risks of contrast induced nephropathy and the short and long-term effects of ionizing radiation.

Philips solutions:

Philips Cardiac Rotational Scan and XperSwing

Philips introduced cardiac rotational angiography in early 2006 to help address these goals by reducing the acquisition runs to typically 3 separate runs using only 24-26 cc of contrast in total.

Philips XperSwing is an improved, innovative adaptation to the cardiac rotational angiography technique to bring further reduction of number of runs and hence contrast usage. It is a unique technique that utilizes a dual-axis rotational coronary angiography in which the rotation can occur in the left anterior oblique (LAO), caudal orientation that ends in the right anterior oblique (RAO), cranial orientation in one single acquisition run. With this technique, it simplifies the typical required acquisition runs to one single acquisition for left and right coronary artery respectively. These unique trajectories are designed to obtain the view of the coronary tree for Left Coronary Artery (LCA) and Right Coronary Artery (RCA). Since these trajectories capture more projections/angles within a “swing”, it may help to reduce the effect of vessel foreshortening and potentially a more complete lesion assessment compared to a lesser projections/angles angiogram study.

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1. [Publication: Catheterization and Cardiovascular Interventions DOI: 10.1002/ccd.23415, 12 Jan 2012](#)

A comparison between dual axis rotational coronary angiography and conventional coronary angiography

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Abstract

Background: Coronary angiography remains the gold standard for the investigation of coronary artery disease, and is carried out in multiple, predefined stationary views, at different angulations around the patient, for both left and right coronary arteries. Dual axis rotational coronary angiography (DARA) is an alternative technique wherein the c-arm rotates around the patient in a preprogrammed single acquisition, exposing the entire coronary artery at different angulations. The DARA system has been recently installed in the Cardiac Catheterisation Suite at Mater Dei Hospital, Malta, where a monoplane and a biplane machine are available. This study was carried out in order to compare DARA with conventional single and biplane coronary imaging, with respect to radiation dose, contrast loads, and procedure time.

Methods: This study was carried out over the period from September to December 2010. Four hundred sixty-three patients were studied. Patients referred for the investigation of native coronary anatomy, for whatever indication, were consented and included, and randomly assigned to one of four groups depending on which machine and modality was used: monoplane conventional, monoplane DARA, biplane conventional, and biplane DARA.

Results: DARA was statistically significantly superior in dose area product, fluoroscopy time, amount of contrast used, and procedure time. These reductions ranged between 12 (contrast used) and 71% (procedure time).

Conclusions: The advantages of such systems are obvious to both patient and healthcare provider, and DARA may prove to be an important and useful tool in the refinement of diagnostic coronary angiography by reducing patient contrast and radiation doses and reducing procedure time.

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Keywords: adult; coronary artery disease; coronary angiography; image processing; computer-assisted; whole-

body irradiation; radiation dosage; prospective studies; fluoroscopy

Take-away remark: Dose results (DAP) include ventriculogram. Reductions for radiation dose ranged from 32.7 % to 61.2%; averagely 41 % contrast savings and average 28% procedure time savings.

2. [Publication: Catheterization and Cardiovascular Interventions DOI: 10.1002/ccd.22804, Sept 2010](#)

Safety and efficacy of dual-axis rotational coronary angiography vs. Standard coronary angiography

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Abstract

Objective: To determine the safety and efficacy of dual-axis rotational coronary angiography (DARCA) by directly comparing it to standard coronary angiography (SA).

Background: Standard coronary angiography (SA) requires numerous fixed static images of the coronary tree and has multiple well-documented limitations. Dual-axis rotational coronary angiography (DARCA) is a new rotational acquisition technique that entails simultaneous LAO/RAO and cranial/caudal gantry movement. This technological advancement obtains numerous unique images of the left or right coronary tree with a single coronary injection. We sought to assess the safety and efficacy of DARCA as compared to SA for screening coronary angiography.

Methods: Thirty patients underwent SA following by DARCA. Contrast volume, radiation dose (DAP) and procedural time were recorded for each method to assess safety. For DARCA acquisitions, blood pressure (BP), heart rate (HR), symptoms and any arrhythmias were recorded. All angiograms were reviewed for CAD screening efficacy by two independent invasive cardiologists.

Results: Compared to SA, use of DARCA was associated with a 51% reduction in contrast, 35% less radiation exposure and 18% shorter procedural time. Both independent reviewers noted DARCA to be at least equivalent to SA with respect to the ability to screen for CAD.

Conclusion: DARCA represents a new angiographic technique which is equivalent in terms of image quality and is associated with less contrast use, radiation exposure and procedural time than SA.

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Keywords: coronary angiography; rotational coronary angiography; dual-axis angiography

Take-away remark: There is significant dose, contrast and time reduction with XperSwing with no patient risk or safety issues. At the same time, there is no missing content with XperSwing versus standard angiogram diagnosis.

3. [Publication: Clinical Cardiology Volume 33, Issue 7, E16-E19, July 2010](#)

A Novel Dual-Axis Rotational Coronary Angiography Evaluation of Coronary Artery Disease — Case Presentation and Review.

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Abstract:

Despite tremendous advances in the invasive and non-invasive evaluation of coronary artery disease (CAD), standard coronary angiography (SA) remains the gold standard diagnostic modality to assess the severity of coronary stenoses. There are significant limitations inherent to fixed-view angiography related to its 2-dimensional (2D) nature and limited number of standard projections acquired. Intravascular ultrasound studies have verified the limited diagnostic accuracy of SA, especially in the setting of complex or eccentric atherosclerotic lesions¹. Furthermore, 3-dimensional (3D) coronary reconstructions have demonstrated the negative impact of vessel overlap and foreshortening on diagnostic accuracy and therapeutic efficiency in screening angiograms and subsequent interventions^{2,3}. The technique of rotational angiography (RA) was developed to enhance the number of images available to more fully assess the complex coronary vasculature from numerous projections and has been found to be clinically useful in decreasing contrast dose, radiation exposure, and overall procedure time with an adequate safety profile and comparable image content to SA⁴⁻⁶. Dual-axis rotational coronary angiography (DARCA) was developed as an innovative adaptation of RA in which rotation occurs in the left anterior oblique (LAO)/right anterior oblique (RAO) and cranial/caudal orientations during 1 cine acquisition to obtain images in a trajectory specifically designed to reduce vessel foreshortening. We present 2 cases demonstrating the novel application of DARCA in optimally defining the significance of specific coronary artery lesions while reducing contrast, radiation exposure, and providing superior lesion imaging.

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Keywords:

Rotational Angiography; dual axis rotation, 3D coronary

Take-away remark: Dual axis rotation (Xperswing) demonstrates significant potential in enhancing the number of angiographic projections obtainable with superior imaging results while reducing safety concerns related to contrast volume and radiation exposure in comparison to Standard Angiography. Lesion assessment with Xperswing was optimized in multiple images which could potentially improve clinical decision making.

4. [Publication: Catheterization and Cardiovascular Interventions 73:753–761 \(2009\)](#)

Rotational vs. Standard Coronary

Angiography: An Image Content Analysis.

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Abstract:

Objective: To evaluate the clinical utility of images acquired from rotational coronary angiographic (RA) acquisitions compared to standard “fixed” coronary angiography (SA).

Background: RA is a novel angiographic modality that has been enabled by new gantry systems

that allow calibrated automatic angiographic rotations and has been shown to reduce radiation and contrast exposure compared to SA. RA provides a dynamic multiple-angle perspective of the coronaries during a single contrast injection.

Methods: The screening adequacy, lesion assessment, and a quantitative coronary analysis (QCA) of both SA and RA were compared by independent blinded review in 100 patients with coronary artery disease (CAD).

Results: SA and RA recognize a similar total number of lesions (P = 0.61). The qualitative assessment of lesion characteristics and severity between modalities was comparable and led to similar clinical decisions. Visualization of several vessel segments (diagonal, distal RCA, posterolateral branches and posterior-descending) was superior with RA when compared to SA (P < 0.05). A QCA comparison (MLD, MLA, LL, % DS) revealed no difference between SA and RA. The volume of contrast (23.5 ± 3.1 mL vs. 39.4 ± 4.1; P = 0.0001), total radiation exposure (27.1 ± 4 vs. 32.1 ± 3.8 Gy·cm²; P = 0.002) and image acquisition time (54.3 ± 36.8 vs. 77.67 ± 49.64 sec; P = 0.003) all favored RA.

Conclusion: Coronary lesion assessment, coronary screening adequacy, and QCA evaluations are comparable in SA and RA acquisition modalities in the diagnosis of CAD however RA decreases contrast volume, image acquisition time, and radiation exposure.

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Key words: angiography coronary; diagnostic cardiac catheterization; contrast media; percutaneous coronary intervention; quantitative coronary angiography

Take-away remark: There is significant dose and contrast with RA compared to SA, with no missing content.

5. [Publication: Catheterization and Cardiovascular Interventions 70:190–196 \(2007\)](#)

Initial Clinical Experience of Selective Coronary Angiography Using One Prolonged Injection and a 180° Rotational Trajectory.

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Abstract:

Objective: Evaluate the safety of prolonged coronary injections during a rotational acquisition covering 180°.

Background: Rotational angiography has been adapted to coronary angiography and shown to reduce radiation and contrast exposure. Three-dimensional (3D) reconstructions and other advanced applications require imaging over a 180°-arc with a single but longer injection of larger contrast volumes.

Methods: Thirty patients referred for angiography were enrolled. Blood pressure (BP), heart rate (HR), symptoms, and ectopy were recorded before-and-after injections.

Results: Pre and post-injection HRs for the LCA/RCA were not statistically different (LCA-pre-injection 63 ± 13 bpm vs. LCA-post-injection 62 ± 11 bpm, $P = 0.54$ and RCA-pre-injection 65 ± 12 bpm vs. RCA-post-injection 65 ± 10, $P = 0.88$). Central aortic pressure values were not statistically different for the RCA injections (RCA-systolic-pre-injection 118 ± 14 mm Hg vs. RCA-systolic-post-injection 112 ± 25 mm Hg, $P = 0.15$, and RCA diastolic-pre-injection 69 ± 9 mm Hg vs. RCA-diastolic-post-injection 60 ± 10 mm Hg, $P = 0.88$) but were statistically significant for the LCA injections (LCA systolic-pre-injection 122 ± 19 mm Hg vs. LCA-systolic-post-injection 116 ± 17 mm Hg, $P = 0.0004$, and LCA-diastolic-pre-injection 69 ± 10 mm Hg vs. LCA-diastolic-post-injection 65 ± 9 mm Hg, $P = 0.0007$). There were no symptoms or electrical events documented during or immediately post-injection.

Conclusion: This study demonstrates the feasibility and safety of longer coronary injections. There were no significant HR

changes, clinically insignificant pressure changes, and no adverse reactions. Additional studies will be needed to assure its safety in a larger and clinically more varied patient population.

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Keywords:

Key words: ANGO-angiography-coronary; CONT-contrast media; HEMO-hemodynamics

Take-away remark: The 3-dimensional coronary modeling (i.e. Philips 3D-CA) is highly feasible and yields more accurate assessments of the lengths of coronary segments than standard QCA.

6. [Publication: International Journal of Cardiovascular Imaging \(2007\) 23:9–13](#)

Rotational angiography (RA) and three-dimensional imaging (3-DRA): an available clinical tool

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Abstract:

Being able to accurately choose an optimal view for stent positioning, non foreshortened length and to avoid side branches is imperative during therapeutic procedures. Traditional imaging limitations may include the selection of an incorrectly sized stent, inaccurate placement, and/or the need for additional stents. With the use of newer acquisition techniques and three-dimensional (3-D) modeling/reconstructions this can be minimized. We present a case in which with the assistance of 3-D and its computer derived optimal view, and optimal length, a significant amount of vessel foreshortening was eliminated therefore improving the procedural outcome.

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Keywords:

Angiography - Three-dimensional (3-D) -
Percutaneous Coronary Intervention

Take-away remark: Three-dimensional imaging resolves many of the 2-D limitations of traditional angiography. With the use of 3-D modelling a rather unconventional but superior working view became evident. With the minimization of foreshortening and overlap, coupled with the actual lesion size and length, the 3-D modelling software optimized the intervention outcome. The accuracy of 3-D length measurements were validated to have an average root-mean-square error of 2.1% in 7 inch FOV and of 2.9% in 9 inch FOV using ten different pairs of angiograms with an intracoronary guidewire of 75-mm length with eight radiopaque markers of 15-mm interdistance.

7. [Publication: Catheterization and Cardiovascular Interventions 64:451–459 \(2005\)](#)

Angiographic Views Used for Percutaneous Coronary Interventions: A Three-Dimensional Analysis of Physician-Determined vs. Computer-Generated Views

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Abstract:

The goal of this study was to determine the severity of vessel foreshortening in standard angiographic views used during percutaneous coronary intervention (PCI). Coronary angiography is limited by its two-dimensional (2D) representation of three-dimensional (3D) structures. Vessel foreshortening in angiographic images may cause errors in the assessment of lesions or the selection and placement of stents. To date, no technique has existed to quantify these 2D limitations or the performance of physicians in selecting angiographic views. Stent deployment was

performed in 156 vessel segments in 149 patients. Using 3D reconstruction models of each patient's coronary tree, vessel foreshortening was measured in the actual working view used for stent deployment. A computer-generated optimal view was then identified for each vessel segment and compared to the working view. Vessel foreshortening ranged from 0 to 50% in the 156 working views used for stent deployment and varied by coronary artery and by vessel segment within each artery. In general, views of the mid circumflex artery were the most foreshortened and views of the right coronary artery were the least foreshortened. Expert-recommended views frequently resulted in more foreshortening than computer-generated optimal views, which had only 0.5% to 1.2% foreshortening with < 2% overlap for the same 156 segments. Optimal views differed from the operator-selected working views by $\geq 108^\circ$ in over 90% of vessels and frequently occurred in entirely different imaging quadrants. Vessel foreshortening occurs frequently in standard angiographic projections during stent deployment. If unrecognized by the operator, vessel foreshortening may result in suboptimal clinical results. Modifications to expert-recommended views using 3D reconstruction may improve visualization and the accuracy of stent deployment. These results highlight the limitations of 2D angiography and support the development of real time 3D techniques to improve visualization during PCI.

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Key words:

coronary angiography; three-dimensional imaging; percutaneous transluminal angioplasty; coronary stenosis

Take-away remark: The data suggested that the 2D imaging limitations of conventional coronary angiography were unrecognized and more prevalent than previously realized. In addition to the subjective

operator-dependent technique of acquiring views, the results reflect the inherent limitations of 2D angiography and the associated imaging inaccuracies that may be imperceptible to the human eye. Three-dimensional reconstruction techniques (Allura 3D-CA) provide an objective model from which accurate measurements can be made and optimal views predicted. The computer algorithm was able to identify better views with less than 3% foreshortening in over 90% of vessel segments. This tool may result in the use of less radiographic contrast, less radiation, and more precise characterization and treatment of obstructive coronary artery disease.

8. [Publication: Catheterization and Cardiovascular Interventions 62:167–174 \(2004\)](#)

Randomized Study of the Safety and Clinical Utility of Rotational Angiography Versus Standard Angiography in the Diagnosis of Coronary Artery Disease

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Abstract:

This study evaluates the safety and clinical utility of rotational angiography in the diagnosis of coronary artery disease. High-speed rotational angiography is a newly available angiographic modality that gives a dynamic multiple-angle perspective of the coronary tree during a single contrast injection. We prospectively randomized 56 patients referred for diagnostic coronary angiography to either standard or rotational angiography. Contrast and radiation utilization were compared between the two groups. The number of additional cine acquisitions needed

was used to determine adequacy of the diagnostic study protocol. Rotational angiography was successfully completed in all subjects. There was a 33% reduction in contrast utilization in the rotational group as compared to the standard group (35.6 ± 12.6 vs. 52.8 ± 10.7 ml, respectively; $P < 0.0001$). Additionally, there was a 28% reduction in total radiation exposure in the rotational group as compared to the standard group (39.0 ± 18.5 vs. 53.9 ± 23.4 Gy_{cm}², respectively; $P = 0.01$). Total whole-body radiation exposure to the primary operator was 144 mrem with rotational angiography and 170 mrem with standard angiography. Procedure time tended to be shorter for rotational angiography (353.9 ± 146.7 vs. 396.8 ± 165.8 s; $P = 0.3$). Rotational coronary angiography can be rapidly performed in any patient and provides a significant reduction in contrast and radiation utilization while at the same time providing adequate angiographic data to complement or replace standard coronary angiography in the evaluation of coronary artery disease.

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Key words: angiography; coronary artery disease

Take-away remark: The rotational angiographic technique provided adequate and sufficient angiographic information for diagnostic coronary angiography. There also was no significant difference in the need for additional image acquisitions between SA and RA; however, there was a substantial reduction in the total number of cinangiographic image acquisitions with rotational angiography.