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TABLE OF CONTENTS

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Editorial

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Patient Quality Measures: The Necessary Paradigm Shifts in Medicine

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Improving patient quality measures is a complex task. It involves more than simply telling caregivers to adopt new practices. Rather, it uses current research and tools to bring about creating changes in workplace attitudes, building teamwork among healthcare providers, and converting evidence based data into actual practice. There are many tools that physicians can use to change practice and improve on quality measures. *Heart Research - Open Journal* is one such tool. This electronic journal is an open access scholarly journal, dedicated to making accessible medical information and research to a wide variety of healthcare individuals. We welcome everyone to our first journal and hope that is a valuable resource for the future. In this edition I am going to discuss changing role of physicians in medical practices as new research and therapy directs us towards better patient care. I will use one particular example that I am very familiar with, and this is the practice of transradial cardiac catheterization.

Change is any practice is difficult, but change for the better is something that we all strive for. In the field of interventional cardiology, for example, our data has suggested that the main advantage of transradial cardiac catheterization and Percutaneous Coronary Intervention (PCI) is reduced access-site complications;[1] the transfemoral approach to cardiac catheterization has been the primary route for cardiac catheterization in the United States. In 2007 transradial catheterization was only being used in 1-3% of all coronary interventions.[1] Since then, however, we have seen a shift and increase in transradial coronary interventions with data suggesting that approximately 16% of coronary interventions were performed *via* radial artery access.[2] Such a shift is an indication of the ability of physicians to adapt and change their practice in the face of an ever changing medical environment.

In 2012 my colleague, Dr. Morton Kern, and I wrote an editorial on the lack of adaption of the transradial technique in the United States.[3] We discussed Kurt Levin's "Unfreeze, Change and Re-freeze" theory. In the early twentieth century social psychologist Kurt Lewin identified three stages of change that are still the basis of many strategies for managing change. He suggested that change involves a move from one static state *via* a state of activity to another static status quo *via* a three-stage process: unfreezing, changing and re-freezing. This freeze change model recognized that people like the safety, comfort and the feeling of control within their environment. Therefore, any change that is threatening to the status quo (frozen state) causes discomfort; and significant effort may be required to 'unfreeze' them in order to get them to change.

In the field of medicine the there is still a tendency for physicians to favor the status quo. More specifically, in interventional cardiology there is the status quo of the transfemoral (TF) approach to cardiac catheterization versus the new challenges of the transradial (TR) approach. The comfortable stasis of the TF procedure compared to the TR alternative, even though TR may offer significant benefit, will cause discomfort. Subsequently any proposed change to this thinking may require an approach from Lewin's three-step "unfreeze-change-refreeze" model.

With new data proposing the benefits of transradial cardiac catheterization we have seen a gradual shift in interventional cardiology practice. In the RIVAL trial,[4] for example, major vascular complication rates were higher in the transfemoral arm (3.7% *vs.* 1.4%, $P < 0.0001$). In addition patients who were enrolled and exhibited ST Elevation Myocardial Infarction (STEMI), the transradial approach was significantly favorable compared

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P = 0.026). Approximately 90% of patients randomized to undergo the TR approach reported preference for the procedure when compared to 49% for the transfemoral arm if the procedure was repeated. Other studies have also shown improved numbers in patient quality and less medical costs when using the transradial approach.[5-7] This change in patterns of behavior have not been to the level that Kuhn[8] spoke about in his book "The Structure of Scientific Revolution," but this is still an indication of physician adaptation and transformation. Kuhn wrote that "successive transition from one paradigm to another *via* revolution is the usual developmental pattern of mature science." I think with TR catheterization we are seeing a slow shift towards transition towards equally perform either TR or TF procedures, depending on what is best for the individual patient.

We commend physicians in making such a significant and patient oriented change in practice. We made a similar change in our practice three-four years ago, and now approximately 80% of our procedures a performed *via* TR access. At our center the cardiology fellows learn this technique during their first month in the cath lab. Our vascular complication rate has attenuated compared when we were performing only TF procedures, and most of our patients now prefer this TR technique. We also perform our pulmonary artery catheterizations *via* venous access in the same arm. In the future as more individuals master this technique the American College of Cardiology (ACC) Core Cardiology Training Symposium (COCATS) guidelines may need to emphasize the importance of training our fellows to master the TR techniques for cardiac catheterization.

A key part of Lewin's model is the idea that change, even at the psychological level, is a journey. This journey may not be that simple and the person may need to go through several steps before the reach their destination. In today's practice of medicine we may be witnessing various shifts from one paradigm to another. If such shifts bring about better quality of patient care then maybe it is time for all physicians to embrace such changes. We hope that tools such as the *Heart Research - Open Journal* will help move such positive changes forward.

References

1. Rao SV, Ou FS, Wang TY, Roe MT, Brindis R, Rumsfeld JS. Trends in the prevalence and outcomes of radial and femoral approaches to percutaneous coronary intervention: a report from the National Cardiovascular Data Registry. *JACC Cardiovasc Interv*. 2008; 1(4): 379-386. doi: 10.1016/j.jcin.2008.05.007

2. Feldman DN, Swaminathan RV, Kaltenbach LA, Baklanov DV, Kim LK, Wong SC. Adoption of radial access and comparison of outcomes to femoral access in percutaneous coronary intervention: an updated report from the national cardiovascular data registry (2007-2012). *Circulation*. 2013; 127(23): 2295-2306. doi: 10.1161/CIRCULATIONAHA.112.000536

3. Patel PM, Kern MJ. Transradial cardiac catheterization: the "unfreeze-change" theory. *Cathet Cardiovasc Intervent*. 2012; 80(2): 258-259. doi: 10.1002/ccd.24530

4. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet*. 2011; 377(9775): 1409-1420. doi: 10.1016/S0140-6736(11)60404-2

5. Cooper CJ, El-Shiekh RA, Cohen DJ, Blaesing L, Burket MW, Basu A. Effect of transradial access on quality of life and cost of cardiac catheterization: A randomized comparison. *Am Heart J*. 1999; 138(3 Pt 1): 430-436. doi: http://dx.doi.org/10.1016/S0002-8703(99)70143-2

6. Amin AP, House JA, Safley DM, Chhatriwalla AK, Giersiefen H, Bremer A. Costs of transradial percutaneous coronary intervention. *JACC Cardiovasc Interv*. 2013; 6(8): 827-834. doi: 10.1016/j.jcin.2013.04.014

7. Roussanov O, Wilson SJ, Henley K, Estacio G, Hill J, Dogan B. Cost-effectiveness of the radial versus femoral artery approach to diagnostic cardiac catheterization. *J Invasive Cardiol*. 2007; 19(8): 349-353.

8. Kuhn, Thomas S. The Structure of Scientific Revolutions, 3rd Ed. Chicago and London: University of Chicago Press; 1996.

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Review

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Coronary CT Angiography in Coronary Artery Disease: from Diagnosis to Prevention

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ABSTRACT

Coronary CT angiography has emerged as reliable imaging tool for the diagnosis of coronary artery disease. Coronary CT angiography has the ability to demonstrate excellent visualization of anatomical changes in coronary artery with high diagnostic value in the detection of lumen stenosis or occlusion, and characterization of coronary plaque composition. Furthermore, coronary CT angiography offers prognostic value in the prediction of adverse cardiac events. Although coronary CT angiography is limited to the assessment of coronary anatomy and lumen changes, coronary CT angiography-derived computer modeling and hemodynamic analysis has the potential to evaluate functional significance of coronary artery disease. This review article aims to provide an overview of both diagnostic and prognostic value of coronary CT angiography in coronary artery disease. Limitations of coronary CT angiography are briefly discussed, while functional assessment of coronary artery disease with use of coronary CT angiography-generated coronary artery models is highlighted.

KEYWORDS: Coronary artery disease, Coronary computed tomography angiography, Diagnosis, Plaque, Prognosis.

INTRODUCTION

There is a growing body of evidence supporting the fact that Coronary CT Angiography (CCTA) is a well-established imaging modality in the diagnosis of Coronary Artery Disease (CAD) due to its less invasiveness, high diagnostic value, and widespread accessibility.[1-7] Diagnostic accuracy of CCTA has been significantly improved with technological advancements in multislice CT scanning techniques, which are represented by the development from early generation of 4-slice CT to 64-slice, dual-source CT and recently available 320-slice CT.[1-11] It has been reported that CCTA has a very high negative predictive value, thus enabling it as a reliable screening tool in patients with low or intermediate risk of CAD.[7-11] This is clinically important as unnecessary invasive coronary angiography or other examinations can be avoided in patients with a normal CCTA. Furthermore, CCTA has the potential to visualize coronary artery wall and plaque morphology, characterize atherosclerotic plaques and identify non-stenotic plaques that may be undetected by invasive coronary angiography. Findings of CCTA are closely related to the clinical outcomes with very low rate of adverse cardiac events occurring in patients with normal CCTA, but with significantly high rates of these events in patients with obstructive CAD.[12-14,15,16]

Despite these promising reports, one limitation of CCTA lies in the high radiation dose which has been well addressed by recently introduced dose-reduction strategies.[8,9,17-20]

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Although CCTA has superior spatial resolution which allows excellent visualization of coronary artery tree and reliable detection of coronary wall changes, another limitation of this technique is that it is still limited to the assessment of morphological changes, but fails to provide functional significance of coronary stenosis. Although recent studies suggest that cardiac CT myocardial perfusion is feasible and provides functional significance of CAD, the diagnostic accuracy suffers from high false positive findings.[21-23] This has been overcome with the use of hemodynamic analysis of blood flow to coronary artery based on numerical simulation using computational fluid dynamic techniques.[24-28] The purpose of this review is to provide an overview of CCTA in CAD, with a focus on the diagnostic and prognostic value. Limitations of CCTA in CAD are discussed while the current research developments with use of CCTA-derived coronary models for simulation of hemodynamic changes are highlighted.

DIAGNOSTIC VALUE OF CCTA IN CAD

The diagnostic value of CCTA in CAD has been significantly augmented with the development of multislice CT scanners and Electrocardiography-Gated (ECG) scanning technique over the last decades. According to several systematic reviews and meta-analyses of 64-slice CCTA studies in the diagnosis of CAD, the sensitivities were more than 97% and specificities were more than 87% in most of the studies.[3,5-7,29,30] These analyses indicate that CCTA has high diagnostic value in the detection and characterization of CAD due to presence of plaques (Figure 1).

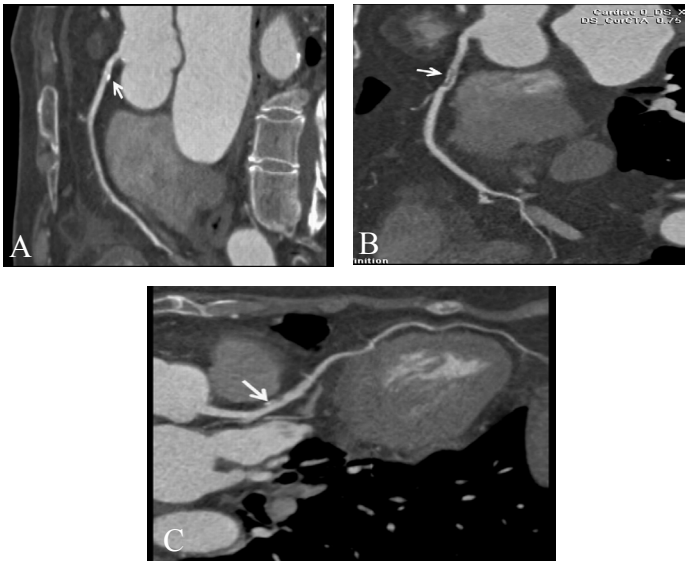

Figure 1: Coronary CT angiography characterization of plaque composition.A. A calcified plaque (arrow) is seen in the proximal segment of right coronary artery in a 65-year-old woman with suspected coronary artery disease. B. A non-calcified plaque (arrow) is detected in the proximal segment of right coronary artery in a 67-year-old woman with known coronary artery disease. C. A mixed plaque (arrow) is observed in the proximal segment of left anterior descending coronary artery in a 55-year-old female with suspected coronary artery disease.

Currently, 320-slice CT represents the recently technological developments in imaging coronary artery disease with good results achieved. Expansion of multislice CT systems from a 64-slice to 320-slice system has allowed for the accurate assessment of stenosis severity and atherosclerotic plaque composition, or even the acquisition of whole-heart coverage in one gantry rotation. Two recently reported systematic reviews and meta-analyses further confirmed the high diagnostic accuracy of 320-slice CCTA.[31,32] The diagnostic sensitivity was similar to that reported in the 64-slice CCTA, but the specificity was higher in 320-slice CCTA than in 64-slice CCTA studies, indicating the high value of 320-slice CCTA for excluding coronary artery stenosis. However, it has to be recognized that diagnostic performance of 320-slice CCTA is similar to that of 64- and 128-slice for the determination of ≥50% coronary artery stenosis due to its limited temporal resolution, despite improved extended z-axis coverage.[33]

Prospectively ECG-triggered CCTA scan (also called step-and-shoot mode) is triggered by the ECG signal and x-ray tube is only turned on at the selected cardiac phase (diastolic), and turned off during the rest of the cardiac cycle. A significant dose reduction with high image quality has been reported in studies performed with prospectively ECG-triggered CCTA (Figure 2).[34-36,37]

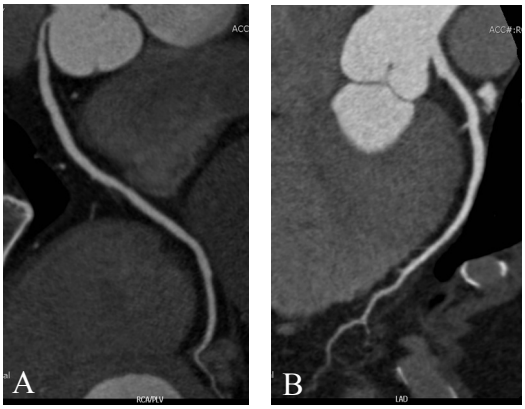

Figure 2: Prospectively ECG-triggered coronary CT angiography in a 54-year-old male with suspected coronary artery disease shows normal right (A) and left coronary arteries (B) with excellent demonstration of anatomical details.

Four systematic reviews and meta-analyses of studies on the use of prospectively ECG-triggered 64-or more slice CCTA reported that the mean patient-based sensitivities and specificities ranged from 99% to 100%, and 89% to 92%, respectively, which is similar to those reported with use of retrospectively ECG-gated CCTA, but with resultant much lower radiation dose.[18,19,38,39] Table 1 summarizes the diagnostic value of these systematic reviews and meta-analyses of studies performed with CCTA in CAD.

PROGNOSTIC VALUE OF CCTA IN CAD

CCTA can detect non-obstructive and non-calcified plaques as well as plaques with positive remodeling, both of which play an important role in the pathophysiology of acute myocardial infarction and may be indicative of vulnerable plaques, which are closely related to the development of major adverse cardiac events.[40,41]

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Type of CT scan	First author	No. of articles in the analysis	Patient-based sensitivity (95% CI)	Patient-based specificity (95% CI)
64-slice coronary CT angiography	Abdulla et al, 2007 (5)	27 studies	97.5% (96-99)	91% (87.5-94)
	Stein et al, 2008 (6)	23 studies	98% (96-98)	88% (85-89)
	Mowatt et al, 2008 (7)	28 studies	99% (97-99)	89% (83-94)
	Sun et al, 2008 (3)	15 studies	97% (94-99)	88% (79-97)
	Guo et al, 2011 (29)	24 studies	98% (99-99)	87% (83-90)
	Salavati et al, 2012 (30)	25 studies	99% (97-99)	89% (84-92)
320-slice coronary CT angiography	Gaudio et al, 2013 (31)	7 studies	95.4% (88.8-98.2)	94.7% (89.1-97.5)
	Li et al, 2013 (32)	10 studies	93% (91-95)	86% (82-89)
Prospectively ECG-triggered coronary CT angiography	Von Ballmoos et al, 2011 (38)	16 studies	100% (98-100)	89% (82-89)
	Sun et al, 2012 (39)	14 studies	99% (98-100)	91% (88-94)
	Sun et al, 2012 (18)	22 studies	97.7% (93.7-100)	92.1% (87.2-97)
	Sabarudin et al, 2013 (19)	23 studies	98.3% (96-100)	90.5% (85.7-96)

Table 1: Diagnostic value ofcoronary CT angiography in coronary artery disease according to systematic reviews and meta-analyses

Studies from single center experience based on short and mid-term follow-up showed that there is a direct correlation between CCTA findings and the occurrence of future cardiac events, as normal CCTA is associated with a very low rate of adverse cardiac events (<1%), while in patients with obstructive CAD as observed on CCTA, the event rate is significantly higher, ranging from 3-59% (Figure 3).[15,16,42-45] Long-term follow-up between 4 and 5 years reported similar results with progressive increase in cardiac event rates in patients with non-obstructive and obstructive CAD as defined by CCTA, while almost 0% event rates in normal coronary arteries.[46-49] Dougoud et al. assessed the prognostic value of CCTA in 218 patients with suspected CAD over a mean period of 6.9 years which represented the longest follow-up with use of 64-slice CCTA.[50] Their results are in line with these reports highlighting the excellent long-term prognosis in normal CCTA with a very low likelihood for cardiac events. Two systematic reviews/meta-analyses on the prognostic value of CCTA also confirmed these findings with low cumulative major adverse cardiac events in patients with normal CCTA findings, but much higher event rates in patients with abnormal CCTA showing obstructive CAD.[51,52]

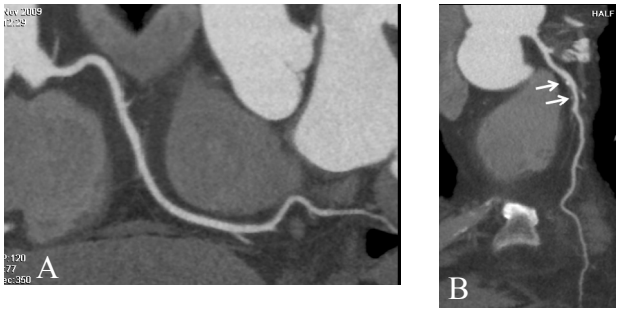

Figure 3.A.Coronary CT angiography shows normal findings in a 66-year-old male with chest discomfort afterexercise. Normal right coronary artery is clearly demonstrated in curved planar reformatted image. B. Coronary CT angiography shows significant stenosis in the left anterior descending (LAD) in the same patient due to presence of mixed plaques as visualized on curved planar reformatted image (arrows).

Goldstein et al. in their multicenter study consisting of 700 patients with acute chest pain symptoms further verified the relationship between CCTA findings and prognostic value of cardiac events.[53] Min et al. in their CONFIRM (Coronary CT Angiography Evaluation for Clinical Outcomes: An International Multicenter Registry) trial evaluated a consecutive cohort of 24,775 patients with suspected CAD who were enrolled at 12 international centers[54] Their results along with others showed that a significant increased risk in adverse cardiac events was observed in patients with CCTA-identified obstructive CAD but with much lower event rates in patients with normal CCTA findings.[54-55,56,57] These results indicate that CCTA could serve as an independent predictor of major adverse cardiac events in patients with suspected CAD, although more studies based on large cohort with long-term follow-up are needed.

LIMITATIONS OF CCTA

Despite rapid technological improvements in CT scanning techniques, CCTA has limitations in the following areas. Firstly, it is a technique with associated high radiation dose which raises concerns in the medical field as there is potential risk of radiation-induced malignancy. With increasing applications of CCTA in the diagnosis of CAD, the research focus has shifted from the previous emphasis on diagnostic value of CCTA to the current focus on reduction of radiation dose with acceptable diagnostic image quality. Using many of the technologies and dose-reduction strategies, it is possible to lower the dose to less than 5mSv, where doses of less than 1mSv is already achievable with the current CT models, which is lower than that of invasive coronary angiography.[8,9,17-20,58-60,61,62] Thus, significant progress has been made over the last decade to lower radiation dose resulting from CCTA.

Secondly, although CCTA allows a comprehensive evaluation of coronary plaques in terms of coronary lumen changes and characterization of plaques (calcified *vs* non-cal

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cified), it is unable to determine which plaques are 'vulnerable' or unstable *versus* those which are stable.[63,64] Therefore, differentiation of lipid-rich content from fibrous content with CCTA remains challenging due to considerable overlap in the attenuation values of lipid and fibrous tissue. Intravascular ultrasound is the gold standard for the assessment of coronary plaque composition and progression in clinical studies.[65,66] Furthermore, extensive coronary artery calcification (coronary calcium score >400) still limits the diagnostic accuracy of CCTA, in particular lowering the sensitivity to some extent due to false positive results, and this is being addressed with improvements in CT imaging.[67,68]

Thirdly, CCTA has superior spatial resolution which allows it to demonstrate excellent visualization of coronary lumen change, however, it has limited value in the diagnostic evaluation of myocardial ischemia. The presence of anatomic lesions does not necessarily correlate with functional significance of CAD, which refers to decreased myocardial perfusion.[69] Studies comparing coronary lesions detected on CCTA with ischemia as documented on myocardial perfusion imaging have shown that CCTA has limited diagnostic value (about 50%) for assessment of abnormal myocardial perfusion in patients with more than 50% coronary stenosis when compared to cardiac ischemia which was confirmed by Single Photon Emission Computed Tomography (SPECT).[70,71] Therefore, SPECT is regarded as the first line diagnostic test for the diagnosis and prognosis of patients with stable CAD as current research evidence is limited with regard to using CCTA as the first line test.[72,73] Table 2 is a summary of characteristics between cardiac SPECT and CCTA in the diagnostic evaluation of CAD.

Characteristics	CCTA	Cardiac SPECT
Diagnostic accuracy	Yes	Yes
Prognostic value	Yes	Yes
Impact on patient management	Uncertain	Yes
Assessment of response to therapy	Uncertain	Yes
Contribution to better outcomes	Uncertain	Yes
Widespread availability	Yes	Yes
Applicable in a wide spectrum of patients	No	Yes
Low radiation dose to patients	Yes	Yes
Cost-effectiveness	Yes	Yes

Table 2: Characteristics of cardiac SPECT and CCTA (modified from reference 72)

CCTA-DERIVED HEMODYNAMIC ANALYSIS

Despite the potential limitations of CCTA in the assessment of hemodynamic significance of anatomic coronary lesions, functional assessment of CAD is an area of active research. In recent years, Computational Fluid Dynamics (CFD) has been increasingly used in the diagnostic evaluation of CAD, with the aim of elucidating the role of hemodynamics in coronary artery disease development and progression, and detecting ischemia-causing coronary lesions.[25-28,74] Promising results have been achieved with use of CFD in patient-specific models for diagnosis of coronary artery disease (Figure 4),[25-28,75-77] although further technical developments of CFD methods and image processing techniques are required to verify these findings.

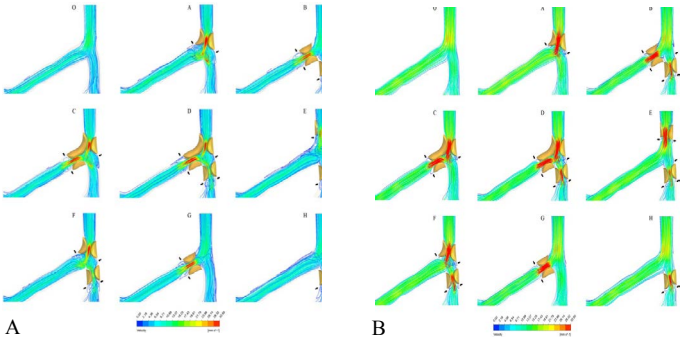

Figure 4: Computational fluid dynamic analysis of the effects of coronary plaques on left coronary blood flow. The velocity patterns inside left coronary bifurcation are demonstrated due to presence of plaque locations with eight types of bifurcation plaques and normal condition during the systolic phase (0.2 s) (A) and diastolic phase (0.7 s) (B).Type O-normal coronary artery tree with no plaque present, plaques involving only the left main stem (type A), involving both left anterior descending (LAD) and left circumflex (LCx) (type B), involving left main stem and LAD (type C), involving left main stem, LAD and LCx (type D), involving proximal left main stem and LCx (type E), involving distal left main stem and LCx (type F), involving LAD only (type G) and LCx only (type H). Reprint with permission from ref (28).

Recently, there has been an increasing interest in the investigation of diagnostic performance of non-invasive Fractional Flow Reserve (FFR) derived from CCTA (FFRCT). Computation of FFRCT is performed by CFD modelling after segmentation of coronary arteries and left ventricular myocardium. 3D blood flow simulations of the coronary arteries are performed with blood modelled as a Newtonian fluid using incompressible Navier-Stokes equations, with implementation of appropriate initial and boundary conditions to the models using a finite element method on a supercomputer.[25-28] The FFRCT ratio is obtained by dividing the mean pressure distal to the coronary stenosis by the mean aortic pressure, which can be measured during CFD simulations. An FFR of ≤0.80 is currently used as a cut off value to determine coronary stenoses responsible for ischemia (Figures 5 and 6).[78,79]

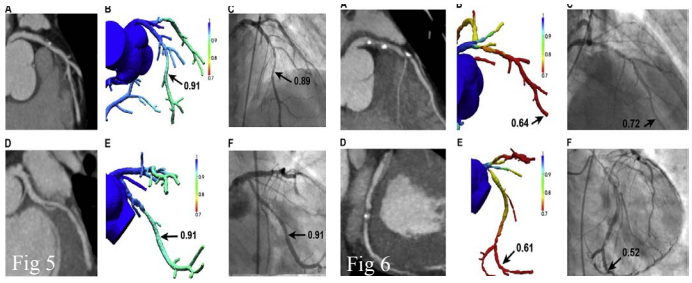

Figure 5: Fractional flow reserve (FFR) derived from CT angiography (FFRCT) results for 66-year-old man with multivessel coronary artery disease but no lesion-specific ischemia. (A) Coronary computed tomography angiography (CCTA) demonstrating stenosis in the left anterior descending coronary artery (LAD). (B) FFRCT demonstrates no ischemia in the LAD, with a computed value of 0.91. (C) Invasive coronary angiography (ICA) with FFR also demonstrates no ischemia in the LAD, with a measured value of 0.89. (D) CCTA demonstrating stenosis in the left circumflex coronary (LCx) artery. (E) FFRCT demonstrates no ischemia in the LCx, with a computedvalue of 0.91. (F) ICA with FFR also demonstrates no ischemia in the LCx, with a measured value of 0.91.Reprint with permission from ref (78).
Figure 6: FFRCT results for 66-year-old man with multivessel CAD and lesion-specific ischemia. (A) coronaryCT angiography(CCTA) demonstrating stenosis in the left anterior descending coronary artery (LAD). (B) FFRCTdemonstrates ischemia in the LAD, with a computed value of 0.64. (C) Invasive coronary angiography (ICA) with FFR also demonstrates ischemia in the LAD, with a measured value of 0.72. (D) CCTA demonstrating stenosis in the left circumflex (LCx). (E) FFRCT demonstrates ischemia in the LCx, with a computed value of 0.61. (F) ICA with FFR also demonstrates ischemia in the LCx, with a measured value of 0.52. Reprint with permission from ref (78).

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Clinical validation of FFRCT is based on a direct comparison to measured FFR during invasive coronary angiography. Currently, there are three multicenter trials, namely DISCOVER-FLOW (Diagnosis of Ischemia-Causing Coronary Stenoses by Noninvasive FFR Computed from Coronary Computed Tomographic Angiograms), DeFACTO (Determination of Fractional Flow Reserve by Anatomic Computed Tomographic Angiography) and NXT (NeXtsTeps) investigating the diagnostic value of FFRCT in CAD.[80-82] On a per-patient analysis, diagnostic sensitivity and specificity of FFRCT ranged from 86-90% and 54-79%, while on a per-vessel analysis, diagnostic sensitivity and specificity of FFRCT were 84% and 86-88%, respectively. Despite the promising results of FFRCT in the detection of flow-limiting coronary stenosis, more multicenter trials need to be performed to compare the clinical impact of FFRCT guided *versus* standard diagnostic evaluation on clinical outcomes, costs and quality of life in patients with suspected coronary artery disease.

SUMMARY AND CONCLUDING REMARKS

Coronary CT angiography has developed as reliable less-invasive imaging modality in the diagnosis of coronary artery disease. Tremendous progress has been made over the last decades in the technological improvements in cardiac CT imaging, thus enabling coronary CT angiography to become a potential alternative to invasive coronary angiography in selected patients. With current CT scanning techniques, coronary CT angiography demonstrates high diagnostic value in coronary artery disease in terms of anatomic lumen assessment. Functional evaluation of significance of coronary stenosis is improving with latest CT models, such as dual-source or dual-energy CT, although the diagnostic accuracy is still inferior to the myocardial perfusion imaging by SPECT. Coronary CT angiography-derived hemodynamic studies and FFRCT show promising clinical outcomes in the diagnostic evaluation of patient-specific lesions. This represents a new research direction in the analysis of cardiovascular hemodynamics and prediction of coronary disease progression. With more research being conducted using advanced cardiac CT imaging techniques and fast computer processing algorithms, it is expected that research findings will provide potential value for improving our understanding of coronary artery disease with regard to pathogenesis and associated complications, thus achieving the goal of early detection of coronary artery disease and prevention of development of major adverse cardiac events.

REFERENCES

1. Sun Z, Cao Y, Li HF. Multislice computed tomography angiography in the diagnosis of coronary artery disease. *J Geriatr Cardiol*. 2011; 8: 104-113. doi: 10.3724/SP.J.1263.2011.00104

2. Sun Z, Jiang W. Diagnostic value of multislice CT angiography in coronary artery disease: A meta-analysis. *Eur J Radiol*. 2006; 60: 279-286. doi: 10.1016/j.ejrad.2006.06.009

3. Sun Z, Lin CH, Davidson R, Dong C, Liao Y. Diagnostic val-ue of 64-slice CT angiography in coronary artery disease: A systematic review. *Eur J Radiol*. 2008; 67: 78-84. doi: 10.1016/j.ejrad.2007.07.014

4. Vanhoenacker P, Heijenbrok-Kal M, Van Heste R, et al. Diagnostic performance of multidetector CT angiography for assessment of coronary artery disease: meta-analysis. *Radiology*. 2007; 244: 419-428. doi: 10.1148/radiol.2442061218

5. Abdulla J, Abildstrom Z, Gotzsche O, et al. 64-multislice detector computed tomography coronary angiography as potential alternative to conventional coronary angiography: a systematic review and meta-analysis. *Eur Heart J*. 2007; 28: 3042-3050.

6. Stein PD, Yaekoub AY, Matta F, Sostman HD. 64-slice CT for diagnosis of coronary artery disease: a systematic review. *Am J Med*. 2008; 121: 715-725. doi: 10.1016/j.amjmed.2008.02.039

7. Mowatt G, Cook JA, Hillis GS, et al. 64-slice computed tomography angiography in the diagnosis and assessment of coronary artery disease: systematic review and meta-analysis. *Heart*. 2008; 94: 1386-1393. doi: 10.1136/hrt.2008.145292

8. Sun Z. Cardiac CT imaging in coronary artery disease: current status and future directions. *Quant Imaging Med Surg*. 2012; 2: 98-105. doi: 10.3978/j.issn.2223-4292.2012.05.02

9. Sun Z, Choo GH, Ng KH. Coronary CT angiography: current status and continuing challenges. *Br J Radiol*. 2012; 85: 495-510. doi: 10.1259/bjr/15296170

10. Johnson T, Nikolaou K, Busch S, et al. Diagnostic accuracy of dual-source computed tomography in the diagnosis of coronary artery disease. *Invest Radiol*. 2007; 42: 484-491. doi: 10.1097/RLI.0b013e31806907d0

11. Pelliccia F, Pasceri V, Evangelista A, et al. Diagnostic accuracy of 320-row computed tomography as compared with invasive coronary angiography in unselected, consecutive patients with suspected coronary artery disease. *Int J Cardiovasc Imaging*. 2013; 29: 443-452. doi: 10.1007/s10554-012-0095-4

12. Schlett CL, Banerji D, Siegel E, et al. Prognostic value of CT angiography for major adverse cardiac events in patients with acute chest pain from the emergency department: 2-year outcomes of the ROMICAT trial. *JACC Cardiovasc Imaging*. 2011; 4: 481-491. doi: 10.1016/j.jcmg.2010.12.008

13. HouZh, Lu B, Gao Y, et al. Prognostic value of coronary CT angiography and calcium score for major adverse cardiac events in outpatients. *JACC Cardiovasc Imaging*. 2012; 5: 990-999. doi: 10.1016/j.jcmg.2012.06.006

14. Carrigan TP, Nair D, Schoenhagen P, et al. Prognostic

utility of 64-slice computed tomography in patients with suspected but no documented coronary artery disease. *Eur Heart J*. 2009; 30: 362-371. doi: 10.1093/eurheartj/ehn605

15. Motoyama S, Sarai M, Harigay H, et al. Computed tomographic angiography characteristics of atherosclerotic plaques subsequently resulting in acute coronary syndrome. *J Am Coll Cardiol*. 2009; 54: 49-57. doi: 10.1016/j.jacc.2009.02.068

16. Pundziute G, Schuijf JD, Jukema JW, et al. Prognostic value of multislice computed tomography coronary angiography in patients with known or suspected coronary artery disease. *J Am Coll Cardiol*. 2007; 49: 62-70. doi: 10.1016/j.jacc.2006.07.070

17. Sabarudin A, Sun Z, Ng KH. A systematic review of radiation dose associated with different generations of multidetector CT coronary angiography. *J Med Imaging Radiat Oncol*. 2012; 56: 5-17. doi: 10.1111/j.1754-9485.2011.02335.x

18. Sun Z, Ng KH. Prospective versus retrospective ECG-gated-multislice CT coronary angiography: A systematic review of radiation dose and image quality. *Eur J Radiol*. 2012; 81: e94-e100.

19. SabarudinA, Sun Z, Ng KH. Coronary CT angiography with-prospective ECG-triggering: A systematic review of image quality and radiation dose. *Singapore Med J*. 2013; 54: 15-23.doi: 10.3978/j.issn.2223-3652.2012.02.04

20. Sabarudin A, Khairuddin Md Yusof A,Tay MF, Ng KH, Sun Z. Dual-source CT coronary angiography: effectiveness of radiationdose reduction with lower tube voltage. *Radiat Prot Dosim*. 2013; 153: 441-447. doi: 10.1093/rpd/ncs127

21. Rocha-Filho JA, Blankstein R, Shturman LD, et al. Incremental value of adenosine-induced stress myocardial perfusion imaging with dual-source CT at cardiac CT angiography. *Radiology*. 2010; 254(2): 410-419. doi: 10.1093/rpd/ncs127

22. Tashakkor AY, Nicolaou S, Leipsic J, Mancini GBJ. The emerging role of cardiac computed tomography for the assessment of coronary perfusion: a systematic review and meta-analysis. *Can J Cardiol*. 2012; 28: 413-422. doi: 10.1016/j.cjca.2012.02.010

23. Techasith T, Cury RC. Stress myocardial CT perfusion: An update and future perspective. *JACC Cardiovasc Imaging*. 2011; 4: 905-916. doi: 10.1016/j.jcmg.2011.04.017

24. Sun Z. Coronary CT angiography: beyond morphological stenosis analysis. *World J Cardiol*. 2013; 5: 444-452. doi: 10.4330/wjc.v5.i12.444

25. Chaichana T, Sun Z, Jewkes J. Computation of haemodynamics in the left coronary artery with variable angulations. *J Biomech*. 2011; 44: 1869-1878. doi: 10.1016/j.jbiomech.2011.04.033

26. Chaichana T, Sun Z, Jewkes J. Impact of plaques in the left coronary artery on walls hear stress and pressure gradient incoronary side branches. *Comput Med Biomech Biomed Eng*. 2014; 17:108-118. doi: 10.1080/10255842.2012.671308

27. Chaichana T, Sun Z, Jewkes J. Hemodynamic impacts of various types of stenosis in the left coronary artery bifurcations: Apatient-specific analysis. *Phys Med*. 2013; 29: 447-452. doi: 10.1016/j.ejmp.2013.02.001

28. Chaichana T, Sun Z, Jewkes. Haemodynamic analysis of the effect of different types of plaque at the left coronary artery. *Comput Med Imaging Graph*. 2013; 37: 197-206. doi: 10.1016/j.compmedimag.2013.02.001

29. Guo SL, Guo YM, Zhai YN, et al. Diagnostic accuracy of first generation dual-source computed tomography in the assessment of coronary artery disease: a meta-analysis from 24 studies. *Int J Cardiovasc Imaging*. 2011; 27: 755-771. doi: 10.1007/s10554-010-9690-4

30. Salavati A, Radmanesh F, Heidari K, et al. Dual-source computed tomography angiography for diagnosis and assessment of coronary artery disease: systematic review and meta-analysis. *J Cardiovasc Comput Tomogr*. 2012; 6: 78-90. doi: 10.1016/j.jcct.2011.10.018

31. Gaudio C, Pellicia F, Evangelista A, et al. 320-row computed tomography angiography vs conventional coronary angiography in patients with suspected coronary artery disease: a systematic review and meta-analysis. *Int J Cardiol*. 2013; 168: 1562-564.

32. Li S, Ni Q, Wu H, et al. Diagnostic accuracy of 320-slice computed tomography angiography for detection of coronary artery stenosis: Meta-analysis. *Int J Cardiol*. 2013; 168: 2699-705. doi: 10.1016/j.ijcard.2013.03.023

33. Sun Z. Comment on: Diagnostic accuracy of 320-slice computed tomography angiography for detection of coronary artery stenosis: meta-analysis (Int J Cardiol, http://dx.doi.org/10.1016/j.ijcard.2013.03.023). *Int J Cardiol*. 2013; 168: 4895-4896. doi: 10.1016/j.ijcard.2013.07.023

34. Sabarudin A, Sun Z, Yusof AK. Coronary CT angiography with single-source and dual-source CT: comparison of image quality and radiation dose between prospective ECG-triggered and retrospective ECG-gated protocols. *Int J Cardiol*. 2013; 168: 746-53. doi: 10.1016/j.ijcard.2012.09.217

35. Earls JP, Berman EL, Urban BA, et al. Prospectively gated transverse coronary CT angiography versus retrospectively gated helical technique: improved image quality and reduced radiation dose. *Radiology*. 2008;246:742-753. doi: 10.1148/radiol.2463070989

36. Shuman W, Branch K, May J, et al. Prospective versus ret

rospective ECG gating for 64-detector CT of the coronary arteries: comparison of image quality and patient radiation dose. *Radiology*. 2008;248:431-7. doi: 10.1148/radiol.2482072192

37. Xu L, Yang L, Zhang Z, et al. Low-dose adaptive sequential scan for dual-source CT coronary angiography in patients with high heart rate: comparison with retrospective ECG gating. *Eur J Radiol*. 2010; 76: 183-187. doi: 10.1016/j.ejrad.2009.06.003

38. vanBallmoos MW, Haring B, Juillerat P, Alkadhi H. Meta-analysis: diagnostic performance of low-radiation-dose coronary computed tomography angiography. *Ann Intern Med*. 2011; 154: 413-420. doi: 10.7326/0003-4819-154-6-201103150-00007

39. Sun Z, Ng KH. Diagnostic value of coronary CT angiography with prospective ECG-gating in the diagnosis of coronary artery disease: a systematic review and meta-analysis. *Int J Cardiovasc Imaging*. 2012; 28: 2109-2119. doi: 10.1007/s10554-011-0006-0

40. Naghavi M, Libby P, Falk E, et al. From vulnerable plaque to vulnerable patient: A callfor new definitions and risk assessment strategies: Part II. *Circulation*. 2003; 108: 1772-1778. doi: 10.1161/01.CIR.0000087480.94275.97

41. Sun Z, Dimpudus FJ, Nugroho J, Adipranoto JD. CT virtual intravascular endoscopy assessment of coronary artery plaques: A preliminary study. *Eur J Radiol*. 2010; 75: e112-e119. doi: 10.1016/j.ejrad.2009.09.007

42. Lou YC, Sun Z, ChanT, et al. Significance of coronary calcification for prediction of coronary artery disease cardiac events-based on 64-slice computed tomography coronary angiography.*Biomed Res Int*. 2013; (2013): 472347. doi: http://dx.doi.org/10.1155/2013/472347

43. Chow BJ, Wells GA, Chen L, et al. Prognostic value of 64-slice cardiac computed tomographyseverity of coronary artery disease, coronary atherosclerosis, and leftventricular ejection fraction. *J Am Coll Cardiol*. 2010; 55:1017-1028. doi: 10.1016/j.jacc.2009.10.039

44. Miszalski-Jamka T, Klimeczek P, Banys R, et al. The composition and extent of coronary artery plaque detected by multislice computed tomographic angiography provides incremental prognostic value in patients with suspected coronary artery disease. *Int J Cardiovasc Imaging*. 2012; 28: 621-631. doi: 10.1007/s10554-011-9799-0

45. Yiu KH, de Graaf FR, Schuijf JD, et al. Age- and gender-specific differences in the prognostic value of CT coronary angiography. *Heart*. 2012; 98: 232-237. doi: 10.1136/heartjnl-2011-300038

46. Andreini D, Pontone G, Mushtaq S, et al. A long-term prognostic value of coronaryCT angiography in suspected coronary artery disease. *JACC Cardiovasc Imaging*. 2012; 5: 690-701. doi: 10.1016/j.jcmg.2012.03.009

47. Sozzi FB, Civaia F, Rossi P, et al. Long-term follow-up of patients with first-time chest pain having 64-slice computed tomography. *Am J Cardiol*. 2011; 107: 516-521. doi: 10.1016/j.amjcard.2010.10.006

48. Hadamitzky M, Taubert S, Deseive S, et al. Prognostic value of coronary computed tomography angiography during 5 years of follow-up in patientswith suspected coronary artery disease. *Eur Heart J*. 2013; 34:3 277-3285. doi: 10.1093/eurheartj/eht293

49. Shaw LJ, Min JK, Narula J, et al. Sex differences in mortalityassociated with computed tomographic angiographic measurements of obstructive and nonobstructive coronary artery disease. *Circ Cardiovasc Imaging*. 2010; 3: 473-481. doi: 10.1161/CIRCIMAGING.109.860981

50. Dougoud S, Fuchs TA, Stehli J, et al. Prognostic value of coronary CT angiography on long-term follow-up of 6.9 years. *Int JCardiovasc Imaging*. 2014; 30: 969-976. doi: 10.1007/s10554-014-0420-1

51. Abdulla J, Asferg C, Kofoed KF. Prognostic value of absence or presence of coronary artery disease determined by 64-slice computed tomography coronary angiography: a systematic review and meta-analysis. *Int J Cardiovasc Imaging*. 2011; 27: 413-420. doi: 10.1007/s10554-010-9652-x

52. Hulten EA, Carbonaro S, Petrillo SP, Mitchell JD, VillinesTC. Prognostic value of cardiac computed tomography angiography: A systematic review and meta-analysis. *J Am Coll Cardiol*. 2011; 57: 1237-1247. doi: 10.1016/j.jacc.2010.10.011

53. Goldstein JA, Chinnaiyan KM, Abidov A, et al. The CT-STAT (Coronary computed tomographic angiography for systematic triage of acute chest painpatients to treatment) trial. *J Am Coll Cardiol*. 2011; 58: 1414-1422. doi: 10.1016/j.jacc.2011.03.068

54. Min JK, Dunning A, Lin FY, et al. Age- and sex-related differences in all-cause mortality risk based on coronary computed tomography angiographyfindings results from the International Multicenter CONFIRM (Coronary CT Angiography Evaluation for Clinical Outcomes: an International Multicenter Registry) of 23,854patients without known coronary artery disease. *J Am Coll Cardiol*. 2011; 58: 849-860. doi: 10.1016/j.jacc.2011.02.074

55. Min JK, Lin FY, Dunning AM, et al. Incremental prognostic significance of left ventricular dysfunction to coronary artery disease detection by 64-detector row coronary computed tomographic angiography for the prediction of all-cause mortality: results from a two centre study of 5330 patients. *Eur Heart J*. 2010; 31: 1212-1219. doi: 10.1093/eurheartj/ehq020

56. Min JK, Feignoux J, Treutenaere J, Laperche T, Sablayrolles J. Theprognostic value of multidetector coronary CT angiography for theprediction of major adverse cardiovascular events: a multicenter observationalcohort study. *Int J Cardiovasc Imaging*. 2010; 26: 721-728. doi: 10.1007/s10554-010-9613-4

57. Hadamitzky M, Freissmuth B, Meyer T, et al. Prognostic value ofcoronary computed tomographic angiography for prediction of cardiacevents in patients with suspected coronary artery disease. *JACC Cardiovasc Imaging*. 2009; 2: 404 -411. doi: 10.1016/j.jcmg.2008.11.015

58. Achenbach S, Marwan M, Ropers D, et al. Coronary computed tomography angiography with a consistent dose below 1 mSv using prospectively electrocardiogram-triggered high-pitch spiral acquisition. *Eur Heart J*. 2010; 31: 340-346. doi: 10.1093/eurheartj/ehp470

59. Lell M, Marvan M, Schepis T, et al. Prospectively ECG-triggered high-pitch spiral acquisition for coronary CT angiography using dual source CT: technique and initial experience. *Eur Radiol*. 2009; 19: 2576-2583. doi: 10.1007/s00330-009-1558-4

60. Lee TY, Chhem RK. Impact of new technologies on dose reduction in CT. *Eur J Radiol*. 2010; 76: 28-35. doi: 10.1016/j.ejrad.2010.06.036

61. Leipsic J, Heilbron BG, Hague C. Iterative reconstruction for coronary CT angiography: findings its way. *Int J Cardiovasc Imaging*. 2012; 28: 613-620. doi: 10.1007/s10554-011-9832-3

62. Sun Z, Ng KH. Coronary computed tomography angiography in coronary artery disease. *World J Cardiol*. 2011; 3: 303-310.

63. Matter CM, Stuber M, Nahrendorf M. Imaging of the unstable plaque: how far have we got? *Eur Heart J*. 2009; 30: 2566-2574. doi: 10.1093/eurheartj/ehp419

64. Hoffmann U, Moselewski F, Nieman K, et al. Noninvasive assessment of plaque morphology and composition in culprit and stable lesions in acute coronary syndrome and stable angina by multidetector computed tomography. *J Am Coll Cardiol*. 2006; 47: 1655-1662. doi: 10.1016/j.jacc.2006.01.041

65. Nissen SE, Nicholls SJ, Sipahi I, et al. Effect of very high-intensitystatin therapy on regression of coronary atherosclerosis: the ASTEROID trial. *JAMA*. 2006; 295: 1556-1565. doi: 10.1001/jama.295.13.jpc60002

66. Nissen SE, Tuzcu EM, Schoenhagen P, et al. Statin therapy, LDL cholesterol, C-reactive protein, and coronary artery disease. *N Engl J Med*. 2005; 352: 29-38. doi: 10.1056/NEJMoa042000

67. Achenbach S, Ropers D, Kuettner A, et al. Contrast-enhanced-coronary artery visualization by dual-source computed tomography-initial experience. *Eur J Radiol*. 2006; 57: 331-335. doi: 10.1016/j.ejrad.2005.12.017

68. Brodoefel H, Burgstahler C, Tsiflikas I, et al. Dual-source CT: effect of heart rate, heart rate variability, and calcification on image quality and diagnostic accuracy. *Radiology*. 2008; 247: 346-355. doi: 10.1148/radiol.2472070906

69. Sato A, Hiroe M, Tamura M, et al. Quantitative measures of coronary stenosis severity by 64-slice CT angiography and relation to physiologic significance of perfusion in nonobese patients: comparison with stress myocardial perfusion imaging. *J Nucl Med*. 2008; 49: 564-572. doi: 10.2967/jnumed.107.042481

70. Hachamovitch R, Di Carli MF. Nuclear cardiology will remain the"gatekeeper" over CT angiography. *J Nucl Cardiol*. 2007; 14: 634-644. doi: 10.1016/j.nuclcard.2007.06.118

71. Tamarappoo BK, Gutstein A, Cheng VY, et al. Assessment of the relationship between stenosis severity and distribution of coronary artery stenoses on multislice computed tomographic angiographyand myocardial ischemia detected by single photon emissioncomputed tomography. *J Nucl Cardiol*. 2010; 17: 791-802. doi: 10.1007/s12350-010-9230-6

72. Trzaska ZJ, Cohen MC. SPECT vs CT: CT is the not the first line test for the diagnosis and prognosis of stable coronary artery disease. *J Nucl Cardiol*. 2013; 20: 473-478. doi: 10.1007/s12350-013-9709-z

73. Alijzeeri A, Cocker MS, Chow BJW. CT vs SPECT: CT is the first-line test for the diagnosis and prognosis of stable coronary artery disease. *J Nucl Cardiol*. 2013; 20: 465-72.

74. Zhang JM, Zhong L, Su B, et al. Perspective on CFD studies of coronary artery disease lesions and hemodynamics: A review. *Int J Numer Metho Biomed Eng*. 2014. doi: 10.1007/s12350-013-9690-6

75. Knight J, Olgac U, Saur SC, et al. Choosing the optimal wall shear parameter for the prediction of plaque location-A patient-specific computational study in human right coronary arteries. *Atherosclerosis*. 2010; 211: 445-450. doi: 10.1016/j.atherosclerosis.2010.03.001

76. Wellnhofer E, Osman J, Kertzscher U, Affeld K, Fleck E, Gou¬bergrits L. Flow simulation studies in coronary arteries--impact of side-branches. *Atherosclerosis*. 2010; 213: 475-448. doi: 10.1016/j.atherosclerosis.2010.09.007

77. Holzapfel GA, Mulvihill JJ, Cunnane EM, Walsh MT. Computational approaches for analyzing the mechanics of atherosclerotic plaques: a review. *J Biomech*. 2014; 47: 859-869. doi: 10.1016/j.jbiomech.2014.01.011

78. Taylor CA, Fonte TA, Min JK. Computational fluid dynamics applied to cardiac computed tomography for noninvasive quantification of fractional flow reserve: Scientific basis. *J Am Coll Cardiol*. 2013; 61: 2233-2241. doi: 10.1016/j.

ISSN 2377-164X Open Journal http://dx.doi.org/10.17140/HROJ-1-101

jacc.2012.11.083

79. Zarins CK, Taylor CA, Min JK. Computed fractional flow reserve (FFRCT) derived from coronary CT angiography. *J Cardiovasc Trans Res*. 2013; 6: 708-714. doi: 10.1007/s12265-013-9498-4

80. Koo BK, Erglis A, Doh JH, et al. Diagnosis of ischemia-causing coronary stenoses by noninvasive fractional flow reserve computed from coronary computed tomographic angiograms. Results from the prospective multicenter discover-flow (diagnosis of ischemia-causing stenoses obtained via noninvasive fractional flow reserve) study. *J Am Coll Cardiol*. 2011; 58: 1989-1997. doi: 10.1016/j.jacc.2011.06.066

81. Min JK, Berman DS, Budoff MJ, et al. Rationale and design of the DeFACTO (Determination of Fractional Flow Reserve by Anatomic Computed Tomographic AngiOgraphy) study. *J Cardiovasc Comput Tomogr*. 2011; 5: 301-309. doi: 10.1016/j.jcct.2011.08.003

82. Norgaard BL, Leipsic J, Gaur S, et al. Diagnostic performance of non-invasive fractional flow reserve derived from coronary CT angiography in suspected coronary artery disease: The NXT trial. *J Am Coll Cardiol*. 2014; 63: 1145-1155. doi: 10.1016/j.jacc.2013.11.043

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Review

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Cardiac Telerehabilitation - Current State and Clinical Perspectives

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ABSTRACT

Cardiovascular Diseases (CVD) are regarded as a leading cause of death globally, constituting important medical, social and economical problem. Systematic reviews and meta-analyses show the positive effect of exercise-based Cardiac Rehabilitation (CR). Despite well-established benefits of CR, many heart failure patients do not attend such programs for a variety of reasons. Cardiac telerehabilitation has the huge potential to deliver CR programs to aforementioned patients. The aim of this study was threefold: to establish the current state of the cardiac telerehabilitation, investigate the extent to which the available opportunities in cardiac telerehabilitation are being exploited, and discuss clinical perspectives and directions of further research.

KEYWORDS: Telemedicine; Cardiac rehabilitation; Telerehabilitation; Clinical applications.

INTRODUCTION

Cardiovascular Diseases (CVD) are regarded as a leading cause of death globally, constituting important medical, social and economical problem. Recent systematic reviews and meta-analyses show the positive effect of exercise-based cardiac rehabilitation (CR). It can significantly reduce the risk of hospital admissions and improve health-related quality of life, moreover exercise training may reduce mortality in the longer term.[1,2] According to the most secondary cardiovascular prevention guidelines, regular exercise training and rehabilitation obtained the class of recommendation I, level of evidence A (indications with type I A evidence) in heart failure patients.[3,4] It can play a critical role in restoring their quality of life, and maintaining (or improving-where available) functional capacity. We should take into consideration that hospital or home-based cardiac rehabilitation programs provide integral care and education concerning cardiovascular risk factors.[4] Components of multidisciplinary CR include: patient assessment, physical activity counselling, exercise training, weight control management, diet/nutritional counselling, lipid management, blood pressure monitoring, smoking cessation, and psychosocial management.[5] Thus such programs are important basic or supplementary way of the cardiovascular diseases prevention and important component of a comprehensive approach to CVD.[6]

Despite well established benefits of CR, many heart failure patients do not attend such programmes for a variety of reasons. Generally CR effects tend to decrease after the initial rehabilitation period.[7] Many patients are inactive, and existing forms of outpatient CR programs may be perceived inappropriate.[3] Additionally, access to CR services may be limited, especially in rural and remote areas.[2] CR seems to be underutilized both in high-, low- and middle-income countries.[8] Usually up to one-third of eligible patients attend a CR program.[9] Importance of CVD prevention seems be not matched by the resources and actions within health care sys-

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-tems.[10] CR support should be more important issue at least for policy makers, healthcare providers, insurers, patients and their families/caregivers. There is need for other approaches increasing access of such patients to the outpatient cardiac rehabilitation. One of them is perceived cardiac telerehabilitation.

Cardiac telerehabilitation has the huge potential to deliver CR programs to aforementioned communities. It is defined as providing CR services at a distance using communication technologies. It makes another breakthrough in providing equitable access to geographically remote, physically disadvantaged, and economically disadvantaged patients and to improve the quality of CR health care. Required optimization of the timing, intensity and duration of therapy can be the same as of the traditional face-to-face treatment. It may significantly improve the implementation of and adherence to CR.[6] Flexible follow-up strategy of cardiac-telerehabilitation and easier access to a specialized team[5] may significantly improve way of secondary prevention and long-term care of cardiac patients. Moreover home-based CR is safe and effective, especially in the area of short-term exercise capacity.[7] Home-based, well-known environment may effectively motivate patients, and simultaneously improve their independence compared with inpatient therapy and care.

The aim of this study was threefold: to establish the current state of the cardiac telerehabilitation, investigate the extent to which the available opportunities in cardiac telerehabilitation are being exploited, and discuss clinical perspectives and directions of further research.

CARDIAC TELEREHABILITATION

Telerehabilitation, new and developing field of telehealth, is defined as providing rehabilitation services at a distance using communication technologies.[11,12] The conceptual framework of telerehabilitation consists of the three areas influencing outcomes of the telerehabilitation: rehabilitative biosystems, human-technology interfaces, and behavioral compliance.[11] Each component of such framework can be used to conceptualize, understand, and optimize whole process and to analyze alternative approaches for optimizing outcomes.[11]

Preliminary evidence of potential cost savings for the healthcare facility thanks to telerehabilitation was provided by Kairy et al.[13] But, we should be aware that identification of clinical outcomes and processes, and possible healthcare utilization and costs associated with telerehabilitation need additional individual research, adapted to the diversity of people, communities, and systems.

Compartmental studies in the area of cardiac telerehabilitation can be very difficult due to huge variety of technical solutions. Systems can range from low-bandwidth low-cost videophones, to expensive, fully immersive virtual reality systems with haptic interfaces.[12] Their basic division can be as follows:

• image-based telerehabilitation - using video conferences and optical measurements within the process of remote counse ling or rehabilitation,

• sensor-based telerehabilitation - using various sensors to assess patient's health status or to supervise rehabilitation process,

• virtual reality-based telerehabilitation (including game-based telerehabilitation) - using semi-realistic interactions for assessment and rehabilitation.

Cardiac telerehabilitation systems usually should be adapted to a variety of Hospital Information Systems (HISs). This makes another challenge for engineers.

CURRENT EVIDENCES

Canadian research by Grace et al.[14] showed, that only 34% of eligible patients participated in CR programs, and member of underrepresented groups are women and ethnic minority groups. There is need for strategies to increase their access to CR programs, where available. There were identified barriers as follows: distance, personal travel, lack of referral and physician recommendation, and - subjectively perceived - low need.[14] Advantages of the universal health care system can be not clear in the case of CR programs. According to the compartmental study by de Melo Ghizi et al.,[8] despite lower availability of CR programs in Brazil, Canadians reported significantly greater (and usually modifiable) barriers than Brazilians (total number of barriers: 21):

• Canadians identified already exercising (at home or in the community), and personal travel,

• Brazilians identified distance and cost of the CR program.[8]

CR programs in Singapore are based on face-to-face treatment, thus recently interactive evidence-based Heart Recovery Education Booklet was introduced as supplementary tool to improve current situation in home-based CR without using telerehabilitation.[15]

Unfortunately there is little research on Home-based Cardiac Telerehabilitation (HTCR). All successful cardiac telerehabilitation programs can be helpful for scientists and clinicians initiating or modifying their own programs. One of them conducted by Piotrowicz et al.[6] showed that HTCR resulted in a significant improvement; moreover, neither deaths nor adverse events were observed. Generally patients accepted HTCR (percentage of non-adherent patients: 0.8). Thus, HTCR may be regarded as a feasible, safe and well-accepted form of rehabilitation by patients. Benefits of hybrid approach, joining ambulatory rehabilitation and home-based telerehabilitation, was recently described by Korzeniowska-Kubacka et al.[16]

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	Traditional face to face rehabilitation	Telerehabilitation
Benefits	Provides continuous direct assessment, monitoring timing, intensity and sequencing of the rehabiltiation, patient-therapist relationship.	Decreases influence of: – inadequate provision of resources, – lack of specialists in a geographic area, – physical distance from health facilities, – lack of transportation, – influence of physical imapairment, – costs. Provides: – continuity of the rehabilitation, – rehabilitation in patient's own environment.
Limitations	– provision of resources and number of specialists, – physical distance from health facilities and lack of transportation – influence of physical imapairment, – costs, – contunuity of procedur es.	– need for changes within strategy and organization of whole heal care system, – low social awareness, – hands-on approach of some treatments, – paucity of online assessment, treatment tools, and outcomes, – aging (of whole societies) and/or disability, – huge variety of technical equipment (possibly decreased thanks to coherent telehealth policy, where available), – huge costs of such system initiation (novel equipment, medical staff education providing their confidence in conducting a safe exercise program, etc.), ethical and legal issues (e.g. licensure laws, responsibility for errors in assessment).
Challenges	Accessibility and efficacy, especially in long term rehabilitation and secondary prevention. Need for common awareness and changes in life style, especially in aging societies.	Uncommon awareness concerning cardiac telerehabiltiation benefits and efficacy evidences. High quality long-term cardiac telerehabilitation programs, including hybrid approaches.

Table 1: Compartment of the traditional face to face rehabilitation and telerehabilitation in terms of their respective benefits, limitations and challenges.

Research of the Working Group on Out-Patient Cardiac Rehabilitation (AGAKAR) demonstrated beneficial short- and long-term effects of the Austrian model of out-patient cardiac rehabilitation.[17]

Dissemination of the knowledge seems to be the most important issue concerning CR (traditional and using telerehabilitation) - nowadays.[18] There is a lack of common awareness among the public about the benefits of CR programs and role of exercise in everyday secondary prevention.[4] Despite there are developed new attractive tools for CR programs (pedometers, continuous monitoring systems),[19,20] they need promotion among potential users.

DIRECTIONS OF FURTHER RESEARCH

Cardiac telerehabilitation becomes commonly accepted as part of the telehealth and everyday clinical prac tice in rehabilitation.[11] Early reports concerning various forms and systems of cardiac telerehabilitation in patients with heart failure are promising.[9] But, current weak scientific base of evidences verifying this group of services must be developed. Further Randomized Controlled Trials (RCTs) are needed to confirm short- and long-term efficacy of cardiac telerehabilitation.[1] Current research showed home-based cardiac telerehabilitation as safe and effective in improving short-term exercise capacity, but novel telemonitoring techniques should support also its long-term effects on physical fitness depending on age, gender, etc.[7] Large scale prospective randomized studies should show equal efficacy of the cardiac telerehabilitation compared to the traditional face-to-face rehabilitation programs. Detailed standards and guidelines, useful for compartmental studies purposes, should be developed.[9]

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There is need for quality indicators which will enable further measurement and improvement of the quality of CR programs.[14] As limitations of further development of the cardiac telerehabilitation systems are perceived also factors shown in Table 1.

There is need for prospect trials and comprehensive analysis where and how structured programs of CR should be delivered.[10] Spectrum of the cardiac telerehabilitation services should be each time adapted to both patients and possibilities of the health care system. Current needs are huge, but rather cost/effect analysis will decide.

CONCLUSIONS

Our review demonstrated that remote cardiac rehabilitation may be regarded as feasible, even compared with conventional face-to-face rehabilitation. This provides support for the development of cardiac telerehabilitation programs, which could be used at patient's home. Further studies should address the feasibility and validity of cardiac telerehabilitation in a home environment. We hope this paper will motivate colleagues to provide more evidences in aforementioned area.

REFERENCES

1. Taylor RS, Sagar VA, Davies EJ, et al. Exercise-based rehabilitation for heart failure. *Cochrane Database Syst Rev*. 2014; 4: CD003331. doi: 10.1002/14651858.CD003331.pub3

2. Tang J, Mandrusiak A, Russell T. The feasibility and validity of a remote pulse oximetry system for pulmonary rehabilitation: a pilot study. *Int J Telemed Appl*. 2012; 2012: 798-791. doi: http://dx.doi.org/10.1155/2012/798791

3. Piotrowicz E. How to do: telerehabilitation in heart failure patients. *Cardiol J*. 2012; 19(3): 243-248.

4. Acevedo M, Krämer V, Bustamante MJ, et al. Exercise and cardiac rehabilitation in secondary cardiovascular prevention [article in Spanish]. *Rev Med Chil*. 2013; 141(10): 1307-1314. doi: 10.4067/S0034-98872013001000010

5. European Association of Cardiovascular Prevention and Rehabilitation Committee for Science Guidelines, EACPR, Corrà U, Piepoli MF, Carré F, et al. Secondary prevention through cardiac rehabilitation: physical activity counselling and exercise training: key components of the position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur Heart J*. 2010; 31(16): 1967-1974. doi: 10.1093/eurheartj/ehq236

6. Piotrowicz E, Korzeniowska-Kubacka I, Chrapowicka A, Wolszakiewicz J, Dobraszkiewicz-Wasilewska B, et al. Feasibility of home-based cardiac telerehabilitation: Results of TeleInterMed study. *Cardiol J*. 2014. doi: 10.5603/CJ.a2014.0005

7. Kraal JJ, Peek N, van den Akker-Van Marle ME, Kemps HM. Effects and costs of home-based training with telemoni toring guidance in low to moderate risk patients entering cardiac rehabilitation: The FIT@Home study. *BMC Cardiovasc Disord*. 2013; 13: 82. doi: 10.1177/2047487314552606

8. de Melo Ghisi GL, Oh P, Benetti M, Grace SL. Barriers to cardiac rehabilitation use in Canada versus Brazil. *J Cardiopulm Rehabil Prev*. 2013; 33(3): 173-179. doi: 10.1097/HCR.0b013e3182930c9f

9. Piotrowicz E, Piotrowicz R. Cardiac telerehabilitation: current situation and future challenges. *Eur J Prev Cardiol*. 2013; 20(2 Suppl): 12-16. doi: 10.1177/2047487313487483c

10. Piepoli MF, Corrà U, Benzer W, et al. Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. Secondary prevention through cardiac rehabilitation: from knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil*. 2010; 17(1): 1-17. doi: 10.1097/HJR.0b013e3283313592

11. Winters JM, Winters JM. A telehomecare model for optimizing rehabilitation outcomes. *Telemed J E Health*. 2004; 10(2): 200-212. doi: 10.1089/tmj.2004.10.200

12. Theodoros D, Russell T. Telerehabilitation: current perspectives. *Stud Health Technol Inform*. 2008; 131: 191-209.

13. Kairy D, Lehoux P, Vincent C, Visintin M. A systematic review of clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation. *Disabil Rehabil*. 2009; 31(6): 427-447. doi: 10.1080/09638280802062553

14. Grace SL, Bennett S, Ardern CI, Clark AM. Cardiac rehabilitation series: Canada. *Prog Cardiovasc Dis*. 2014; 56(5): 530-535.doi: 10.1016/j.pcad.2013.09.010

15. Wang W, Thompson DR, Chow A, Kowitlawakul Y. An education booklet to aid cardiac patients' recovery at home. *Int Nurs Rev*. 2014. doi: 10.1111/inr.12091

16. Korzeniowska-Kubacka I, Dobraszkiewicz-Wasilewska B, Bilińska M. i wsp. Two model sof early cardiac rehabilitation in male patients after myocardial infarction with preserved left ventricular function: comparison of standard out-patient versus hybrid training programmes. *Kardiol Pol*. 2011; 69(3): 220-226.

17. Niebauer J, Mayr K, Harpf H, et al. Long-term effects of outpatient cardiac rehabilitation in Austria: a nationwide regis try. Wien Klin Wochenschr. 2014; 126(5-6): 148-155. doi: 10.1007/s00508-014-0527-3

ISSN 2377-164X Open Journal http://dx.doi.org/10.17140/HROJ-1-102

18. Griffo R, Temporelli PL, Fattirolli F, et al. ICAROS (Italian survey on CardiAc RehabilitatiOn and Secondary prevention after cardiac revascularization): temporary report of the first prospective, longitudinal registry of the cardiac rehabilitation network GICR/IACPR [article in Italian]. *Monaldi Arch Chest Dis*. 2012; 78(2): 73-78.

19. Frederix I, Dendale P, Berger J, Vandereyt F, Everts S, Hansen D. Comparison of two motion sensors for use in cardiac telerehabilitation. *J Telemed Telecare*. 2011; 17(5): 231-234. doi: 10.1258/jtt.2010.100914

20. Helmer A, Kretschmer F, Deparade R, et al. A system for the model based emergency detection and communication for the telerehabilitation training of cardiopulmonary patients. *Conf Proc IEEE Eng Med Biol Soc*. 2012; 2012: 702-706. doi: 10.1109/EMBC.2012.6346028

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Impact of Resistance Training on Quality of Life and Ischemia Modified Albumin Levels in Men with Cardiovascular Risk Factors

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ABSTRACT

Purpose: There are limited data concerning the effects of Resistance Training (RT) on the components of Quality of Life (QOL) and Ischemia Modified Albumin (IMA) serum levels, even though QOL is an important characteristic related to the treatment success involving non communicable diseases. Studies regarding IMA and physical activity have focused only in the acute effects of exercise. Thereby, the purpose of this study is to investigate the effects of a moderate intensity RT on Health-related Quality of Life (HRQoL) and IMA levels in men with cardiovascular risk factors.

Methods: Nineteen sedentary men (59 ± 8.63 years old) with metabolic syndrome (MS) components underwent a RT with sessions three times a week, comprising 12 exercises, during 12 weeks. The Short-Form 36 was administered to evaluate the domains of physical and mental components of HRQOL pre and post-intervention. Body composition and serum biochemical parameters were analyzed.

Results: Volunteers had total body fat content and total muscle mass unchanged along the intervention. With regard to serum analysis, triglycerides and IMA levels remained unchanged with RT, while increased HDL levels ($p < 0.001$) and reduced ratio between total and HDL cholesterol ($p = 0.006$) were observed. Moreover, improvements in the HRQOL subscales of role-physical ($p = 0.048$), general health ($p < 0.001$), vitality ($p < 0.001$), social functioning ($p = 0.044$) and mental health ($p = 0.006$) were verified after the RT.

Conclusions: It was concluded that a moderate RT is useful in providing benefits on quality of life in men with cardiovascular risk factors, despite the maintenance of IMA levels.

KEYWORDS: Quality of Life; Middle aged; Strength training; Health, Metabolic Syndrome X; Ischemia-modified serum albumin.

MAIN KEY FINDINGS

- Resistance training provides improvements on physical and mental components of quality of life in men with cardiovascular risk factors;
- Benefits on quality of life outcomes afforded by moderate resistance training are independent of changes in ischemia modified albumin levels and body composition adaptations.

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ABBREVIATIONS: BMI: Body Mass Index; CVD: Cardiovascular diseases; HDL: High-density cholesterol; HRQoL: Health-related Quality of Life; IMA: Ischemia Modified Albumin; LDL: Low-Density Cholesterol; MS: Metabolic Syndrome; QoL: Quality of Life; RT: Resistance Training; SF-36: 36-Item Short-Form Health Survey; TC: Total Cholesterol; 1RM: One maximal repetition.

INTRODUCTION

It is widely known that sedentary lifestyle and high caloric diets are related to the development of Cardiovascular diseases' (CVD) risk factors, such as hypertension, insulin resistance, dyslipidemia and central obesity.[1] In this regard, evidences demonstrate that middle-aged and elderly male have more frequently unknown diabetes, hypertension, apolipoprotein and cytokines levels than women,[2] besides android fat distribution that accelerate CVD onset. Moreover, Brazil is among the first five countries in the world with the biggest number of obese people,[3] with men presenting almost 10% more unconditional probability of dying between 30 and 70 years old due to non-communicable diseases than women in the same conditions (rates of 479/10,000 and 333/10,000 in 2010, respectively).[4] In addition to the main traditional risk factors of CVD,[1] increased Ischemia Modified Albumin (IMA) levels reflect a reduced capacity of albumin to bind to cobalt, which is considered a marker of myocardial ischemia and myocardial necrosis linked to inflammation and hyperglycemia,[5] despite criticisms of low specificity in clinical practice. In this respect, very few studies have investigated the effects of relatively few weeks of intervention with exercise training on IMA levels.

There are few data concerning Quality of Life (QoL) outcomes and Resistance Training (RT) in sedentary men with Metabolic Syndrome (MS), when compared with aerobic training.[6] In this sense, a better Health-related Quality of Life (HRQoL) is influenced by increased adherence to therapies and reduced use of medications and number of hospitalizations in patients with diabetes and/or MS.[7,8] An impaired QoL is recognized as a predictor of increased CVD risk[9] and obese individuals were found to have worse HRQoL, more mentally unhealthy days and more activity-limiting days than healthy adults.[10] The regular physical exercise has been strongly recommended for the prevention and treatment of CVD and their risk factors.[11] Moderate intensity RT, for instance, promotes whole-body insulin sensitivity,[12] mitochondrial[13] and cardiovascular system adaptations.[11] Considering that there are limited data about the impact of RT as a unique intervention on self-reported QoL in middle-aged and elderly male and that studies regarding IMA and physical activity have focused in the acute effects of exercise, this study has the purpose of investigating the effects of a moderate intensity RT on HRQoL and IMA levels in men with cardiovascular risk factors. We hypothesize that 12 weeks of moderate intensity RT in middle-aged and elderly male would improve physical components of HRQoL and decrease the IMA levels.

MATERIALS AND METHODS

Subjects

After media advertisements about the study and a meeting where they were fully informed about the protocol, nineteen men were recruited to participate. The inclusion criteria consisted of being sedentary men (no participation in regular and structured exercises in the previous six months), non smokers, aged between 45 and 74 years old, body mass index (BMI) > 25 kg/m² and the presence of the following risk factors: triglycerides levels ≥ 150 mg/dL or specific drug treatment, High-Density Cholesterol (HDL) levels ≤ 40 mg/dL or specific drug treatment, fasting glucose levels ≥ 100 mg/dL or specific drug treatment, systolic blood pressure ≥ 130 and/or diastolic ≥ 85 mmHg or specific drug treatment and waist circumference ≥ 90 cm.[1] It is clear that each of the above characteristics is treated as independent cardiovascular risk factor, and these may or may not act in an additive manner.[1] Men with liver, renal and heart diseases, muscular or joint disability were excluded from the study. It is clear that each of the above characteristics is treated as independent cardiovascular risk factor, and these may or may not act in an additive manner.[1] Besides, the subjects were instructed to maintain their habitual food intake during the intervention. This study was approved by the institutional Ethics Committee (permit number: 0032.0.243.000-07), was in accordance to the Declaration of Helsinki and all the participants signed a written informed consent.

Resistance Training

The supervised RT took place in the Physical Education and Sports Center gym of the Universidad Federal de Santa Maria and was performed three days per week during 12 weeks, with 48-72 h of recovery between sessions. In the beginning of the RT sessions, there was a low intensity indoor walking for 10 min. The 12-week RT consisted of the following exercises, alternating upper and lower resistance machines: chest press, rower machine, lat pull-down, triceps pulley extension, biceps curl, leg press, leg curl, ankle plantar flexion, hip abduction and adduction, trunk extension and abdominals. After one week of adaptation in which the volunteers performed two sets of 12 repetitions in each exercise, they performed three sets of 12 repetitions until the end of the training. The exercises of RT were established at 50% of one Maximal Repetition (1MR), and a good technique practice was emphasized, reducing the potential for excessive muscle soreness and injury.[11] In the end of sessions, the stretching was performed individually, with emphasis in the upper and lower back, shoulders, arms, chest, abdomen, thighs and calves.

Functional Assessments

To estimate the largest load that an individual can

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move in a single maximal effort and thus prescribe the training load, a submaximal test was used to estimate the 1MR in the bench press, rower machine, leg press and knee flexion exercises.[14] The cardiorespiratory fitness was assessed with Bruce's modified treadmill protocol.[15] Moreover, the resting levels of systolic and diastolic blood pressure were measured with a digital sphygmomanometer (Omron, Kyoto, Japan) and the flexibility of lumbar and hamstring muscles were assessed by the sit-and-reach test.[16]

Anthropometric Measurements

The subjects were weighted in a scale (Plenna, São Paulo, Brazil), heighted in a stadiometer (Cardiomed, Curitiba, Brazil) and the abdominal circumference was measured with a spring-loaded metal tape (Cardiomed, Curitiba, Brazil). Total body fat and muscle contents were estimated by the tetrapolar impedance technique (Maltron, Rayleigh, UK), according to manufacturer's instructions.

Biochemical Assays

After 12 h fasting and 48 h without exercise practice, the blood samples were taken from an antecubital vein. The samples were drawn into serum separator tubes (BD Diagnostics, Plymouth, UK) and routinely centrifuged at 1500 g for 15 min. Afterwards, the serum was frozen at -80 ºC until analysis. The triglycerides, Total Cholesterol (TC) and HDL levels were determined spectrophotometrically, with commercially available assay kits (Labtest, Lagoa Santa, Brazil). The concentration of low-density cholesterol (LDL) was estimated[17] and the TC/HDL ratio was also calculated. The levels of IMA were measured calorimetrically on a automated analyzer (Cobas MIRA®, Roche Diagnostics, Basel, Switzerland), based on albumin's properties of bind to cobalt as previously described.[5]

Quality of Life

The HRQoL was assessed using the 36-Item Short-Form Health Survey (SF-36), which was previously translated and validated to the Brazilian population.[18] It should be emphasized that a bibliographic study about the growth of QoL measures identified SF-36 as the most widely generic used questionnaire in the evaluation of patients' health.[19] The scoring of each of the eight subscales (physical functioning, role-physical, bodily pain, vitality, general health, social functioning, role-emotional, and mental health) range from 0 (poor state) to 100 (good state of HRQoL) and were calculated by standard scoring protocol.[20]

Statistical Analysis

After the Shapiro-Wilk normality test was performed, Student's t test or Wilcoxon Rank Test were used to determine significant differences between the pre and post-training means. The Statistical Package for Social Sciences (SPSS 14.0, Chicago, USA) was used and statistical significance was set at $p < .05$. The data were expressed as mean ± standard deviation.

RESULTS

The analyzed sample (M = 59, SD = 8.63 years old) comprised six former smokers and thirteen nonsmokers. Moreover, 42.10% of them took antihypertensive agents, 31.50% took lipid-lowering agents and 26.30% took oral hypoglycemic agents. Table 1 demonstrates that RT resulted in increased levels of diastolic blood pressure [$t(18) = -2.45$, $p = .025$], greater distance reached in flexibility test [$t(18) = -4.96$, $p < .001$] and increased VO_2 max [$t(18) = -2.16$, $p = .044$] levels. Furthermore, volunteers presented decreased total exercise test duration [$t(18) = -2.167$, $p = .044$] and TC/HDL ratio [$t(18) = 3.12$, $p = .006$] and increased TC [$t(18) = -2.34$, $p = .031$] and HDL levels [$t(18) = -5.76$, $p < .001$] in comparison with baseline levels. Contrary to our hypothesis, 12 weeks of moderate intensity RT did not decrease IMA levels in middle-aged and elderly male. Other anthropometric, functional and biochemical variables did not change after the exercise intervention.

Variables	Pre-training	Post-training
Body Mass (kg)	93.66 ± 16.30	94.2 ± 16.68
BMI (kg/m²)	31.46 ± 5.56	31.63 ± 5.62
Abdominal Circumference (cm)	109.64 ± 12.31	109.57 ± 13.13
Total Muscle Mass (kg)	63.19 ± 6.38	63.02 ± 6.15
Total Body Fat Content (kg)	31.62 ± 10.25	31.85 ± 10.64
Systolic Blood Pressure (mmHg)	124.21 ± 17.31	128.42 ± 16.87
Diastolic Blood Pressure (mmHg)	70.94 ± 10.79	75.94 ± 10.35*
Total Exercise Test Duration (min)	9.26 ± 2.72	9.6 ± 2.55*
VO_2 max (mL/kg/min)	34.88 ± 8.00	35.89 ± 7.52*
Sit-and-reach test (cm)	17.74 ± 10.87	19.97 ± 10.45**
Triglycerides (mg/dL)	147.45 ± 71.59	139.14 ± 83.62
Total Cholesterol (mg/dL)	217.31 ± 43.05	241.42 ± 56.36*
HDL (mg/dL)	45.57 ± 12.86	60.15 ± 20.29**
TC/HDL	4.97 ± 1.25	4.21 ± 1.05**
LDL (mg/ dL)	142.24 ± 38.26	153.43 ± 51.42
IMA (UABS)	0.468 ± 0.069	0.482 ± 0.121

Values expressed as mean ± SD. BMI: Body Mass Index. VO_2max: maximal oxygen uptake. HDL: High-Density Cholesterol. LDL: Low-Density Cholesterol. IMA: Ischemia Modified Albumin. UABS: Units of Absorbance. * $p < 0.05$ post *vs.* pre resistance training.

Table 1: Anthropometric, functional and biochemical characteristics of men with metabolic syndrome risk factors pre and post-training.

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Table 2 shows the results of the submaximal strength test pre and post-training. Increases in the load moved in the bench press [t(18) = -9.07, p < .001], leg press [t(18) = -5.26, p < .001], rower machine [t(18) = -14.14, p < .001] and knee flexion [t(18) = -8.63, p < .001] exercises were observed.

Exercises	Pre-training	Post-training
Bench Press (kg)	58.83 ± 17.31	68.45 ± 17.88**
Leg Press (kg)	124.55 ± 22.67	138.56 ± 25.28**
Rower machine(kg)	44.12 ± 6.62	54.96 ± 8.38**
Knee Flexion (kg)	17.50 ± 2.59	21.78 ± 2.39**

**p < 0.01 and *p < 0.01 post *vs.* pre-training.

Table 2: Load moved in the strength test pre and post-training.

As to HRQoL, men with cardiovascular risk factors showed increases on the role-physical [t(18) = -2.92, p = .048], general health [t(18) = -2.92, p < .001], vitality [t(18) = -4.79, p < .001], social functioning [t(18) = -2.22, p = .044] and mental health [t(18) = -3.01, p = .006] scoring scales after the training protocol (see Table 3).

Scales	Pre-training	Post-training
Physical Functioning	83.15 ± 12.38	84.31 ± 11.69
Role-physical	65.78 ± 29.11	78.94 ± 33.60*
Bodily Pain	67.89 ± 22.48	69.00 ± 21.96
General Health	67.84 ± 20.19	74.94 ± 16.91**
Vitality	55.26 ± 6.34	74.73 ± 16.02**
Social Functioning	79.6 ± 22.13	89.47 ± 15.73*
Role-emotional	75.43 ± 33.03	84.21 ± 34.00
Mental Health	75.15 ± 17.81	81.68 ± 16.12**

Values are expressed as mean ± SD. *p < 0.05 and **p < 0.01 post *vs.* resistance training.

Table 3: SF-36 questionnaire subscales scoring of men with cardiovascular risk factors pre and post-training

DISCUSSION

The main findings in this study include that a 12-week moderate intensity RT improved QoL parameters, both in physical (role-physical and general health) and mental components (vitality, social functioning and mental health) in men with cardiovascular risk factors. Middle-aged and elderly men also demonstrated increases on HDL and TC/HDL parameters, despite no changes in body composition and IMA levels after the exercise intervention. Moreover, the moderate intensity RT program was sufficient to induce functional adaptations, such as increases in lumbar and hamstring muscles' flexibility, in VO_2max values, in the total time elapsed in cardiorespiratory test and loads moved in the strength tests. RT is known for reducing body fat percentage and increasing lean body mass.[8-11] However, our results did not corroborate these findings, as well as previously studies encompassing moderate intensity RT.[21-22] Thus, it is speculated that more intensive RT programs and/or more weeks of training are necessary to significantly improve body composition parameters in men.

Increased levels of HDL induced by RT are clinically relevant, since previous studies suggest that HDL possess anti-atherogenic and antioxidant properties by inhibiting LDL oxidation, anti-inflammatory functions as it inhibits pro inflammatory signalling cascades, besides antiplatelet and antithrombotic functions, stimulating reverse cholesterol transport and providing a decreased risk of CVD.[23] In this regard, another study showed that elevated systemic levels of HDL were accompanied by the modulation of lipoprotein lipase and hepatic lipase activities in sedentary individuals who underwent six months of aerobic training.[24] The mechanisms by which moderate intensity RT may increase the HDL levels are yet to be elucidated. With regard to TC/HDL ratio, a RT thrice a week lasting 9 weeks also induced a decreased ratio (~17.5%)[25], similar to our findings (~15.5%).

Most investigations involving IMA and physical activity have focused on the acute effects of exercise,[26-29] but only one study was found to investigate the chronic effects of exercise training (aerobic) in non-athletes[30] and no studies were found regarding RT and IMA levels. In this matter, three months of moderate-intensity walking unchanged IMA levels in type 2 diabetes mellitus patients, while its levels increased in the sedentary group.[30] The authors argue that the unchanged IMA levels in exercised group may be a result of increased antioxidant markers concentrations provided by physical training, which can prevent oxidation changes of albumin and, consequently, IMA synthesis.[30] Another hypothesis is that the decreased blood pressure obtained as a result of aerobic training may improve circulation and prevent ischemia, partially inhibiting the increase of IMA levels.[30] In our study, RT did not decrease blood pressure values. The effects of other RT programs on IMA levels and/or with other populations require further clarification.

A recent meta-analysis reported that adults with higher BMI had reduced physical HRQoL, with a dose relationship across all BMI categories, while mental HRQoL was only reduced in grade III obese subjects.[31] In this context, associations have been demonstrated between obesity and anxiety and depression disorders, particularly among severe obese individuals and women.[32] Our findings corroborate the hypothesis that weight loss is not mandatory for improvements in HRQoL when cardiovascular fitness is increased in obese individuals.[33] Accordingly, a study with young men demonstrated associations between higher physical fitness levels and increased scores in vitality and general and mental health subscales of HRQoL.[34] In fact, it is clear that a better QoL is linked to reduced health public costs.[7,8] Most studies involving physical training and

HRQoL have studied the consequences of an aerobic training on QoL outcomes,[6] leaving aside the RT. In our study, a 12-week RT performed three times a week improved role-physical, general health, vitality, social functioning and mental health domains. Similarly, studies demonstrated that RT performed thrice a week for 7 weeks benefits QoL, mental health and well-being of sedentary adults[35] and that QoL subscales of vitality and social functioning were improved by 10-week RT in depressed elder.[36] In this regard, data published elsewhere showed associations between muscle strength and QoL and that its improvement facilitates the performance in daily living activities, such as climbing stairs, dressing, cleaning and carrying objects.[8] On the same line of research, previous data suggest that the preservation of muscle strength promoted by RT may positively impact functional outcomes and health indices related to QoL.[37] This study includes as limitations the small sample size, the lack of a control group and that seasonal factor that may have influenced blood pressure levels along the intervention.

CONCLUSION

In conclusion, it was demonstrated that resistance training presents positive effects on physical and mental components of health-related quality of life, despite the maintenance of ischemia modified albumin levels in men with cardiovascular risk factors. Future trials are necessary to investigate the impact of different resistance training protocols in quality of life parameters, since its understanding is important for the reduction of health public costs.

DISCLOSURE OF INTEREST

The authors declare no conflict of interest concerning this article.

REFERENCES

1. Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention. National Heart, Lung, and Blood Institute, American Heart Association, World Heart Federation, International Atherosclerosis Society and International Association for the Study of Obesity. *Circulation.* 2009;120(16):1640-1645. doi: 10.1161/CIRCULATIONAHA.109.192644

2. Regitz-Zagrosek V, Lehmkuhl E, Weickert MO. Gender differences in the metabolic syndrome and their role for cardiovascular disease. *Clin Res Cardiol.* 2006; 95(3): 136-1347. doi: 10.1007/s00392-006-0351-5

3. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014; 384(9945):766-781. doi: 10.1016/S0140-6736(14)60460-8

4. Stevens A, Schmidt MI, Duncan BB. Gender inequalities in non communicable disease mortality in Brazil. *Cien Saude Colet.* 2012; 17(10): 2627-2634. doi: http://dx.doi.org/10.1590/S1413-81232012001000012

5. Kaefer M, Piva SJ, De Carvalho JA, et al. Association between ischemia modified albumin, inflammation and hyperglycemia in type 2 diabetes mellitus. *Clin Biochem.* 2010; 43(4-5): 450-454. doi: 10.1016/j.clinbiochem.2009.11.018

6. van der Heijden MM, van Dooren FE, Pop VJ, Pouwer F. Effects of exercise training on quality of life, symptoms of depression, symptoms of anxiety and emotional well-being in type 2 diabetes mellitus: a systematic review. *Diabetologia*. 2013; 56(6): 1210-1225. doi: 10.1007/s00125-013-2871-7

7. Zhang X, Norris SL, Chowdhury FM, Gregg EW, Zhang P. The effects of interventions on health-related quality of life among persons with diabetes: a systematic review. *Med Care*. 2007; 45(9): 820-834. doi: 10.1097/MLR.0b013e3180618b55

8. Levinger I, Goodman C, Hare DL, Jerums G, Selig S. The effect of resistance training on functional capacity and quality of life in individuals with high and low numbers of metabolic risk factors. *Diabetes Care.* 2007; 30(9): 2205-2210. doi: 10.2337/dc07-0841

9. Lidfeldt J, Nyberg P, Nerbrand C, Samsioe G, Schersten B, Agardh CD. Socio-demographic and psychosocial factors are associated with features of the metabolic syndrome. The Women's Health in the Lund Area (WHILA) study. *Diabetes Obes Metab.* 2003; 5(2): 106-112. doi: 10.1046/j.1463-1326.2003.00250.x

10. Ford ES, Li C. Metabolic syndrome and health-related quality of life among U.S. adults. *Ann Epidemiol.* 2008; 18(3): 165-171. doi: 10.1016/j.annepidem.2007.10.009

11. Williams MA, Haskell WL, Ades PA, et al. Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. *Circulation.* 2007; 116(5): 572-584. doi: 10.1161/CIRCULATIONAHA.107.185214

12. Klimcakova E, Polak J, Moro C, et al. Dynamic strength training improves insulin sensitivity without altering plasma levels and gene expression of adipokines in subcutaneous adipose tissue in obese men. *J Clin Endocrinol Metab*. 2006; 91(12): 5107-5112. doi: http://dx.doi.org/10.1210/jc.2006-0382

13. Hurley BF, Hanson ED, Sheaff AK. Strength training as a countermeasure to aging muscle and chronic disease. *Sports*

Med. 2011; 41(4): 289-306. doi: 10.2165/11585920-000000000-00000

14. Guedes D, Guedes J. Manual prático para avaliação em educação física. *Barueri: Manole*. 2006.

15. Bruce RA, Kusumi F, Hosmer D. Maximal oxygen intake and nomographic assessment of functional aerobic impairment in cardiovascular disease. *Am Heart J.* 1973; 85(4): 546-562. doi: 10.1016/0002-8703(73)90502-4

16. Taguchi N, Higaki Y, Inoue S, Kimura H, Tanaka K. Effects of a 12-month multicomponent exercise program on physical performance, daily physical activity, and quality of life in very elderly people with minor disabilities: an intervention study. *J Epidemiol.* 2010; 20(1): 21-29. doi: http://dx.doi.org/10.2188/jea.JE20081033

17. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem.* 1972; 18(6): 499-502.

18. Ciconelli R, Ferraz M, WWS, Meinão I, Quaresma R. Brazilian-portuguese version of SF-36: a reliable and valid quality of life outcome measure. *Rev Bras Reumatol.* 1999; 39: 143-150.

19. Garrat A, Schmidt L, Mackintosh A, Fitzpatrick R. Quality of life measurement: bibliographic study of patient assessed health outcome measures. *BMJ.* 2002;15: 324(7351): 1417. doi: http://dx.doi.org/10.1136/bmj.324.7351.1417

20. Ware JE, Kosinski M. Interpreting SF-36 summary health measures: a response. *Qual Life Res*. 2001; 10(5): 405-413. doi: 10.1023/A:1012588218728

21. Plotnikoff RC, Eves N, Jung M, Sigal RJ, Padwal R, Karunamuni N. Multicomponent, home-based resistance training for obese adults with type 2 diabetes: a randomized controlled trial. *Int J Obes (Lond)*. 2010; 34(12): 1733-1741. doi: 10.1038/ijo.2010.109

22. Misra A, Alappan NK, Vikram NK, et al. Effect of supervised progressive resistance-exercise training protocol on insulin sensitivity, glycemia, lipids, and body composition in Asian Indians with type 2 diabetes. *Diabetes Care*. 2008; 31(7): 1282-1287. doi: 10.2337/dc07-2316

23. Berrougui H, Momo CN, Khalil A. Health benefits of high-density lipoproteins in preventing cardiovascular diseases. *J Clin Lipidol.* 2012; 6(6): 524-533. doi: 10.1016/j.jacl.2012.04.004

24. Duncan GE, Perri MG, Theriaque DW, Hutson AD, Eckel RH, Stacpoole PW. Exercise training, without weight loss, increases insulin sensitivity and postheparin plasma lipase activity in previously sedentary adults. *Diabetes Care.* 2003; 26(3): 557-562. doi: 10.2337/diacare.26.3.557

25. Costa RR, Lima Alberton C, Tagliari M, Martins Kruel LF. Effects of resistance training on the lipid profile in obese women. *J Sports Med Phys Fitness.* 2011; 51(1): 169-177.

26. Roy D, Quiles J, Sharma R, et al. Ischemia-modified albumin concentrations in patients with peripheral vascular disease and exercise-induced skeletal muscle ischemia. *Clin Chem.* 2004; 50(9):1656-1660. doi: 10.1373/clinchem.2004.031690

27. Middleton N, Shave R, George K, et al. Novel application of flow propagation velocity and ischaemia-modified albumin in analysis of postexercise cardiac function in man. *Exp Physiol.* 2006; 91(3): 511-519. doi: 10.1113/expphysiol.2005.032631

28. Apple FS, Quist HE, Otto AP, Mathews WE, Murakami MM. Release characteristics of cardiac biomarkers and ischemia-modified albumin as measured by the albumin cobalt-binding test after a marathon race. *Clin Chem.* 2002; 48(7): 1097-1100.

29. Falkensammer J, Stojakovic T, Huber K, et al. Serum levels of ischemia-modified albumin in healthy volunteers after exercise-induced calf-muscle ischemia. *Clin Chem Lab Med*. 2007; 45(4): 535-540. doi: 10.1515/CCLM.2007.087

30. Kurban S, Mehmetoglu I, Yerlikaya HF, Gonen S, Erdem S. Effect of chronic regular exercise on serum ischemia-modified albumin levels and oxidative stress in type 2 diabetes mellitus. *Endocr Res.* 2011; 36(3): 116-123. doi: 10.3109/07435800.2011.566236

31. Ul-Haq Z, Mackay DF, Fenwick E, Pell JP. Meta-analysis of the association between body mass index and health-related quality of life among adults, assessed by the SF-36. *Obesity (Silver Spring)*. 2013; 21(3): E322-E327. doi: 10.1002/oby.20107

32. Scott KM, Bruffaerts R, Simon GE, et al. Obesity and mental disorders in the general population: results from the world mental health surveys. *Int J Obes (Lond)*. 2008; 32(1): 192-200. doi: 10.1038/sj.ijo.0803701

33. Rejeski WJ, Lang W, Neiberg RH, et al. Correlates of health-related quality of life in overweight and obese adults with type 2 diabetes. *Obesity (Silver Spring)*. 2006; 14(5): 870-883. doi: 10.1038/oby.2006.101

34. Hakkinen A, Rinne M, Vasankari T, Santtila M, Hakkinen K, Kyrolainen H. Association of physical fitness with health-related quality of life in Finnish young men. *Health Qual Life Outcomes.* 2010; 8: 15. doi: 10.1186/1477-7525-8-15

ISSN 2377-164X Open Journal http://dx.doi.org/10.17140/HROJ-1-103

35. Taspinar F, Aslanb UB, Agbugac B, Taspinara F. A comparison of the effects of hatha yoga and resistance exercise on mental health and well-being in sedentary adults: A pilot study. *Complement Ther Med.* 2014; 22(3): 433-440. doi: 10.1016/j.ctim.2014.03.007

36. Singh NA, Clements KM, Fiatarone MA. A randomized controlled trial of progressive resistance training in depressed elders. *J Gerontol A Biol Sci Med Sci.* 1997; 52(1): M27-M35. doi: 10.1093/gerona/52A.1.M27

37. Hurley BF, Roth SM. Strength training in the elderly: effects on risk factors for age-related diseases. *Sports Med.* 2000; 30(4): 249-268. doi: 10.2165/00007256-200030040-00002

HEART RESEARCH

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Letter to the Editor

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A Comprehensive Cardiovascular Preventive Clinic: Is it a Concept that is Possible to Implement in the Military System?

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ABSTRACT

Cardiovascular disease has a huge impact on our society and the individuals affected. According to the most recent data published by American Heart Association (2014 Update), Coronary heart disease alone caused about 1 in 6 deaths in the United States in 2010. In 2010, the senior author attempted to explore the concept of truly comprehensive cardiovascular preventive clinics with goal driven protocols and operated by mid-level providers with different backgrounds from clinical pharmacy to advanced nurse practitioners. The concept, design and implementation of the Preventive Cardiology Clinic at Brooke Army Medical Center using a multi-disciplinary approach with evidence based protocols and standard operating procedures in a patient-centered design enhanced patient participation and optimized success in preventive care in a high-risk population. The Preventive Cardiology Clinic resulted in improved identification and screening of cardiovascular patients at risk, improved implementation of preventive therapies and achievement of target goals, significantly affected tobacco cessation success rates that surpasses nationally reported success rates, and improved quality of life. We feel this concept could be easily replicated using existing resources in most military and other medical treatment facilities

KEYWORDS: Cardiovascular prevention; Lipid disorders; Smoking cessation; Peripheral arterial disease.

COMMENTARY

Cardiovascular disease has a huge impact on our society and the individuals affected. According to the most recent data published by American Heart Association (2014 Update), Coronary heart disease alone caused about 1 in 6 deaths in the United States in 2010. Each year about 620,000 Americans have a new coronary attack and about 295,000 have a recurrent attack. The total direct and indirect cost of CVD and stroke in the United States for 2010 is estimated to be $315.4 billion.[1] As the national focus continues to be on health care utilization, care and quality it becomes increasingly important that we try to address the multiple modifiable risk factors that have been shown to improve cardiovascular outcomes. Very little has been published regarding comprehensive prevention in a combined approach utilizing a cardiovascular prevention clinic.

In 2010, the senior author attempted to explore the concept of truly comprehensive cardiovascular preventive clinics with goal driven protocols and operated by mid-level providers with different backgrounds from clinical pharmacy to advanced nurse practitioners. The vision of the clinic was to streamline cardiovascular screening, medical management, and prevention programs in order to provide more efficient and higher quality care for the service members with ultimate goal

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of reducing long term outcomes and cost utilization. The clinic currently utilizes a clinical pharmacist, physician assistant, and advanced nurse practitioners as well as an exercise physiologist and technicians with peripheral support by nutrition and psychology and supervised by the founder and the senior author, Ahmad M. Slim. Currently, the clinic evaluates for and treats lipid disorders, Hypertension (HTN), Diabetes Mellitus (DM), Peripheral Arterial Disease (PAD), Screening Abnormal Calcium Score, Tobacco dependence, and provides weight loss management and dedicated exercise program for weight loss and claudication treatment. Screening and treatment is based on the most recent evidenced-based guidelines published and updated annually,[2-5] and written up into strict standard operating procedures for all mid-providers within the clinic to follow. The clinic is part of the patient centered home model with a multi-disciplinary approach.

The current patient demographics based on preliminary review for quality assurance and process improvement purpose produced 1800 patients with 60% male predominance and an average age of 64 years+/- 10.4. The average Framingham Risk Score was 14%+/- 8.3%, diabetics compromised 30%and smokers 15% of the population. 221 patients had an abnormal calcium score upon enrollment with an average score of 178 ± 323. Data on 88 participants enrolled in the smoking cessation program collected includes class attendance, cessation, and abstinence rates at 1, 6, and 12 months. Initial pull showed that participants in the smoking cessation classes were very successful with 78% abstinence at 3 months and 49% abstinence at 6 months compared to 25% for the national average (Figure 1). We evaluated the impact of class attendance as well as type of intervention utilized on regular basis to constantly improve delivery of care and implement changes that will maintain the success rate or improve it (Figure 2 and 3). The data shows a significant improvement in smoking cessation rates when patients use Varenicline (Chantix®) as compared with other medication or no medications and also when patients attend 4 or more cessation classes.

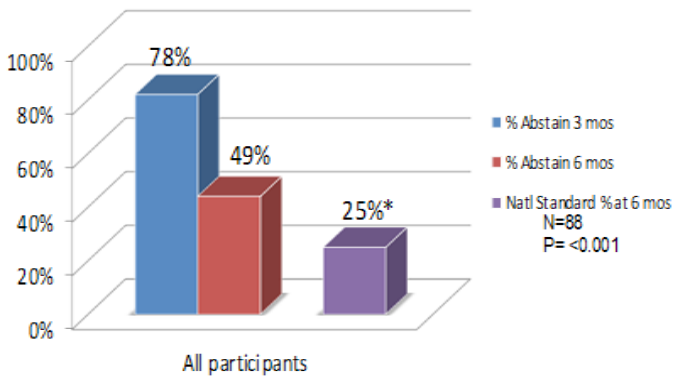

Figure 1: Abstinence rates vs. the National average. *Hunt WA, et al. J Clinical Psych, 1971; 27:455-56

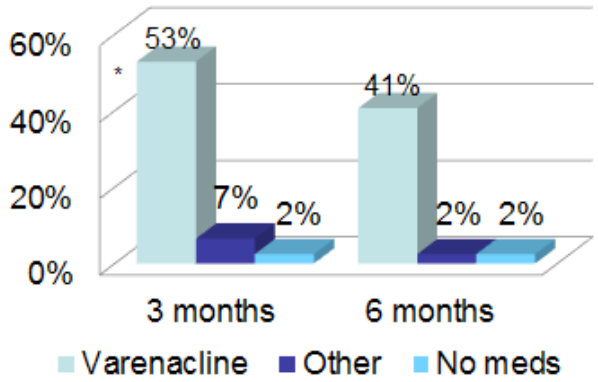

Figure 2: Abstinence Rates by Medication (Completed Course)

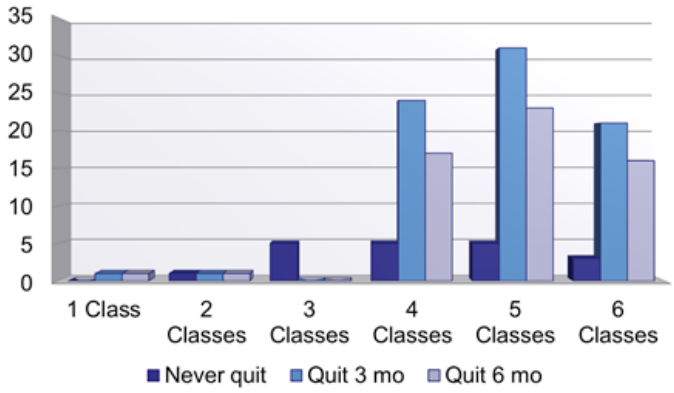

Figure 3: Class attendance and Cessation

The preventive cardiology clinic goal for lipid management was for LDL cholesterol to be less than 100. Data pulled on 1800 patients showed that 38% of patients were at goal prior to being seen by the clinic and a significant increase to 78% of patients with LDL cholesterol at goal was seen. Figure 4 shows these stats as compared to current HEDIS measures with a goal of 40%. These percentages are also significantly better when compared to only 18% of patients with CHD meet a goal LDL<100.[6]

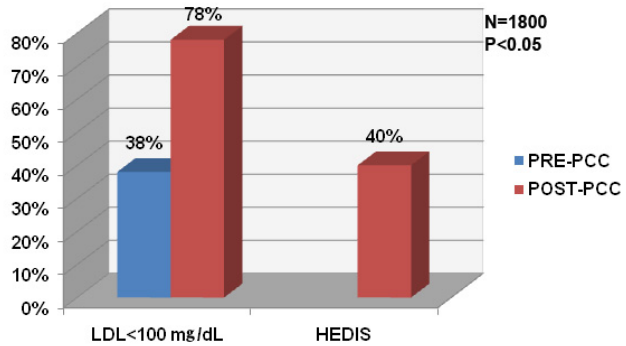

Figure 4: Pre vs. Post Preventive Cardiology Clinic LDL goal comparisons

The initial vascular data is also promising, 9 patients were found to have vascular disease and participated in

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a structure exercise program in order to try to help increase their exercise capacity. The patients underwent supervised exercise therapy in a cardiac rehab facility. The patients had 5 sessions per week (2 were supervised) where they exercised on a treadmill to near maximal claudication pain. The participants were in the program for greater than 3 months and the results showed significant improvements in walking distance and overall quality of life. The patients were able to increase the amount they could exercise on average from 9.3 minutes to 21.7 minutes and also increase their speed from 1.8 mph to 2.4 mph after completing the exercise program (Figure 5). In addition to the above data regarding tobacco cessation, lipids, and exercise improvement, there are additional endpoints that were successful with regard to blood pressure management, coronary calcium score, and diabetes management. The additional data will follow in a more comprehensive data pull in a future article.

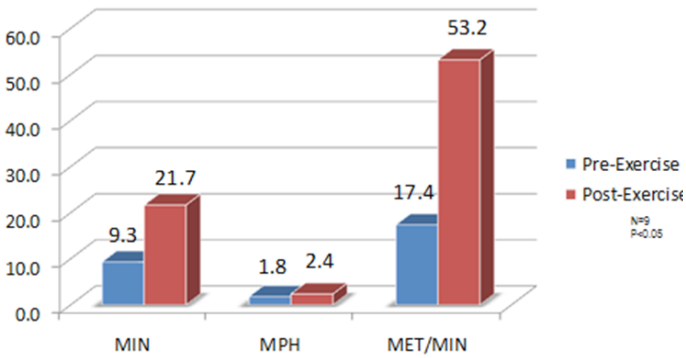

Figure 5: Improvements in exercise capacity in peripheral artery disease patients

In summary, the concept, design and implementation of the Preventive Cardiology Clinic at Brooke Army Medical Center using a multi-disciplinary approach with evidence based protocols and standard operating procedures in a patient-centered design enhanced patient participation and optimized success in preventive care in a high-risk population. This work aligns with published data from 10 European countries and Israel where primary care systems with cardiovascular disease focus had better overall outcomes and strength as compared to programs with broad overall life style modification program.[7]

The Preventive Cardiology Clinic resulted in improved identification and screening of cardiovascular patients at risk, improved implementation of preventive therapies and achievement of target goals, significantly affected tobacco cessation success rates that surpasses nationally reported success rates, and improved quality of life. We feel this concept could be easily replicated using existing resources in most military and other medical treatment facilities.

CONFLICT OF INTERESTS

The opinions in this manuscript do not constitute endorsement by San Antonio Army Medical Center, the U.S. Army Medical Department, the U.S. Army Office of the Surgeon General, the Department of the Army, Department of Defense, or the U.S. Government of the information contained therein. The authors declare that there is no conflict of interests regarding the publication of this article.

REFERENCES

1. Go AS, Mozaffarian D, Roger VL, et al. On behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics-2014 update: a report from the American Heart Association. *Circulation*. https://my.americanheart.org/idc/groups/ahamah-public/@wcm/@sop/@smd/documents/downloadable/ucm_459072.pdf. 2013; Accessed 2013.

2. Anderson JL, Halperin JL, Albert NM, et al. Management of Patients With Peripheral Artery Disease (Compilation of 2005 and 2011ACCF/AHA Guideline Recommendations): A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2013; 127(13): 1425-1443. doi: 10.1161/CIR.0b013e31828b82aa

3. Naghavi M, Falk E, Hecht HS, Shah PK. SHAPE Task Force. The first SHAPE (Screening for Heart Attack Prevention and Education) guideline. *Crit Pathw Cardiol*. 2006; 5(4): 187-190. doi: 10.1097/01.hpc.0000249784.29151.54

4. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation*. 2002; 106(25): 3143-3421.

5. American Diabetes Association. Standards of Medical Care in Diabetes-2013. *Diabetes Care*. 2013; 36(Supp.1): S11-S66. doi: 10.2337/dc13-S011

6. Pearson TA, Laurora I, Chu H, Kafonek S. The lipid treatment assessment project (L-TAP): a multicenter survey to evaluate the percentages of dyslipidemic patients receiving lipid-lowering therapy and achieving low-density lipoprotein cholesterol goals. *Arch Intern Med*. 2000; 160:459-467. doi: 10.1001/archinte.160.4.459

7. vanLieshout J, Wensing M, Campbell SM, Grol R. Primary care strength linked to prevention programs for cardiovascular disease. *Am J Manag Care*. 2009; 15(4): 255-262. http://www.ajmc.com/publications/issue/2009/2009-04-vol15-n4/AJMC_09Apr_Lieshout_255to262/