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e-Cardiology
ESC Working Group

EUROPEAN SOCIETY OF CARDIOLOGY®

eHealth on the agenda of the ESC

Cardiovascular Imaging on Mobile Devices.

Is it Feasible?

Disclosure Statement of Financial Interest

- *None*

ESC eHealth

EUROPEAN
SOCIETY OF
CARDIOLOGY®

ESC eHealth Task-Force

- The leadership of the ESC has identified that ehealth is a very important topic for the comming years and has put it on top of their agenda.
- The past-president of the ESC, Prof. Panos Vardas eluded to this extensively during his farwell speech at the annual ESC Congress in Barcelona in 2014.
- The recognition of the importance of eHealth has resulted into the initiative of a taskforece eHealth which was started early 2014.
- The task-force has the following members: Martin R Cowie, Jeroen Bax (ESC president-Elect), Nico Bruining, John GF Cleland, Frederich Koeler, Marek Malik, Fausto Pinto (ESC president), E van de Velde, Panos Vardos (ESC past-president)

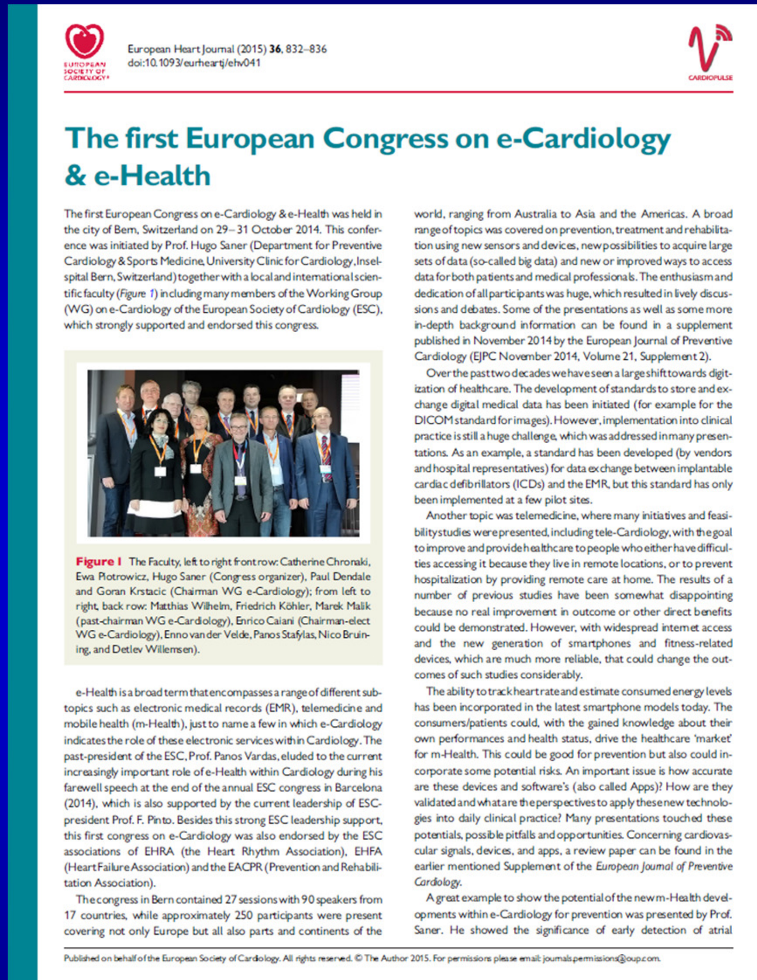
ESC eHealth Task-Force and Position Paper

- Paper based on discussions between Board members of the ESC (including its Executive Officers), members of the Working Group on e-cardiology, and members of the CRT that took place during a workshop in Brussels on 9 April 2014.
- It aims to highlight the key aspects of e-health that relate to CV health and the delivery of healthcare to individuals with, or at risk, of CVD.
- Paper to reflect the current position of the ESC on e-health.
- The vision of the ESC is to play a pro-active role in all aspects of the e-health agenda, helping to develop, assess, and implement effective ICT innovations in the support of cardiovascular health and health-related activity across Europe.
- The paper is currently under review at the European Heart Journal

Key ESC deliverables defined in the fields of:

- **Education and training**
  - of its members in the appropriate use of e-health, including all seven domains listed in the introduction to this Paper
- **Regulation /quality control**
  - Active role in discussions regarding regulation and quality control of ICT technologies as they relate to CVD in Europe, including (where appropriate) setting benchmark quality standards for relevant technologies
  - Active role in the societal and political discussions regarding data security and confidentiality issues, particularly with regard to its members working in countries with different legal constraints
- **Research & Development**
  - To support research into the development, evaluation, and implementation of e-health technologies and innovation, with an emphasis on establishing the clinical and cost-effectiveness of such innovation – ethics?
- **Advocacy**
  - To promote policy dialogue related to e-health at local, national and international level with all relevant stakeholders, including government, regulators, payers, professional bodies, citizens, patients, health care professionals, and industry
  - To provide a resource for citizens in the member countries to assist them in assessing the potential benefit and any associated risks of e-health applications in cardiovascular disease prevention, diagnosis and treatment.

European Congress on e-Cardiology & e-Health



European Heart Journal (2015) **36**, 832–836
doi:10.1093/eurheartj/ehv041

The first European Congress on e-Cardiology & e-Health

The first European Congress on e-Cardiology & e-Health was held in the city of Bern, Switzerland on 29–31 October 2014. This conference was initiated by Prof. Hugo Saner (Department for Preventive Cardiology & Sports Medicine, University Clinic for Cardiology, Inselspital Bern, Switzerland) together with a local and international scientific faculty (*Figure 1*) including many members of the Working Group (WG) on e-Cardiology of the European Society of Cardiology (ESC), which strongly supported and endorsed this congress.

Figure 1 The Faculty, left to right front row: Catherine Chronaki, Ewa Piotrowicz, Hugo Saner (Congress organizer), Paul Dendale and Goran Krstacic (Chairman WG e-Cardiology); from left to right, back row: Matthias Wilhelm, Friedrich Köhler, Marek Malik (past-chairman WG e-Cardiology), Enrico Caiani (Chairman-elect WG e-Cardiology), Enno van der Velde, Panos Stafylas, Nico Bruining, and Detlev Willemsen).

e-Health is a broad term that encompasses a range of different subtopics such as electronic medical records (EMR), telemedicine and mobile health (m-Health), just to name a few in which e-Cardiology indicates the role of these electronic services within Cardiology. The past-president of the ESC, Prof. Panos Vardas, eluded to the current increasingly important role of e-Health within Cardiology during his farewell speech at the end of the annual ESC congress in Barcelona (2014), which is also supported by the current leadership of ESC-president Prof. F. Pinto. Besides this strong ESC leadership support, this first congress on e-Cardiology was also endorsed by the ESC associations of EHRA (the Heart Rhythm Association), EHFA (Heart Failure Association) and the EACPR (Prevention and Rehabilitation Association).

The congress in Bern contained 27 sessions with 90 speakers from 17 countries, while approximately 250 participants were present covering not only Europe but all also parts and continents of the world, ranging from Australia to Asia and the Americas. A broad range of topics was covered on prevention, treatment and rehabilitation using new sensors and devices, new possibilities to acquire large sets of data (so-called big data) and new or improved ways to access data for both patients and medical professionals. The enthusiasm and dedication of all participants was huge, which resulted in lively discussions and debates. Some of the presentations as well as some more in-depth background information can be found in a supplement published in November 2014 by the European Journal of Preventive Cardiology (EJPC November 2014, Volume 21, Supplement 2).

Over the past two decades we have seen a large shift towards digitization of healthcare. The development of standards to store and exchange digital medical data has been initiated (for example for the DICOM standard for images). However, implementation into clinical practice is still a huge challenge, which was addressed in many presentations. As an example, a standard has been developed (by vendors and hospital representatives) for data exchange between implantable cardiac defibrillators (ICDs) and the EMR, but this standard has only been implemented at a few pilot sites.

Another topic was telemedicine, where many initiatives and feasibility studies were presented, including tele-Cardiology, with the goal to improve and provide healthcare to people who either have difficulties accessing it because they live in remote locations, or to prevent hospitalization by providing remote care at home. The results of a number of previous studies have been somewhat disappointing because no real improvement in outcome or other direct benefits could be demonstrated. However, with widespread internet access and the new generation of smartphones and fitness-related devices, which are much more reliable, that could change the outcomes of such studies considerably.

The ability to track heart rate and estimate consumed energy levels has been incorporated in the latest smartphone models today. The consumers/patients could, with the gained knowledge about their own performances and health status, drive the healthcare 'market' for m-Health. This could be good for prevention but also could incorporate some potential risks. An important issue is how accurate are these devices and software's (also called Apps)? How are they validated and what are the perspectives to apply these new technologies into daily clinical practice? Many presentations touched these potentials, possible pitfalls and opportunities. Concerning cardiovascular signals, devices, and apps, a review paper can be found in the earlier mentioned Supplement of the *European Journal of Preventive Cardiology*.

A great example to show the potential of the new m-Health developments within e-Cardiology for prevention was presented by Prof. Saner. He showed the significance of early detection of atrial

New Congress possibly in summer 2016

Cardiovascular Imaging on Mobile Devices.

Is it Feasible?

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Thoraxcenter, Erasmus MC, Rotterdam, The Netherlands

Cardiovascular Imaging on Mobile Devices. Is it Feasible?

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Short communication

Smartphones, tablets and mobile applications for radiology

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ABSTRACT

Background: Smartphones are phone devices that may also be used for browsing, navigation and running smaller computer programs called applications. One may consider them as compact personal computers which are primarily to be used for making phone calls. Tablets or "tablet PCs" are fully functioning standalone computers the size of a thin LCD monitor that use the screen itself for control and data input. Both of these devices may be categorized based on the mobile operating system that they use. The aim of this study is to illustrate how smartphones and tablets can be used by diagnostic imaging professionals, radiographers and residents, and to introduce relevant applications that are available for their field.

Materials and methods: A search was performed on iTunes, Android Market, Blackberry App World, and Windows Phone Marketplace for mobile applications pertinent to the field of diagnostic imaging. The following terms were applied for the search strategy: (1) radiology, (2) X-ray, (3) ultrasound, (4) MRI, (5) CT, (6) radiographer, (7) nuclear medicine. Two radiologists and one radiology resident reviewed the results. Our review was limited to english-language software. Additional applications were identified by reviewing the list of similar software provided in the description of each application. We downloaded and installed all applications that appeared relevant to an appropriate mobile phone or tablet device.

Results: We identified and reviewed a total of 102 applications. We ruled out 1 non-English application and 20 other applications that were created for entertainment purposes. Thus our final list includes 81 applications in the following five categories: diagnostic reading, decision support applications, medical books, interactive encyclopedias, and journal reading programs.

Conclusion: Smartphones and tablets offer new opportunities for diagnostic imaging practitioners; these easy-to-use devices equipped with excellent display may be used for diagnostic reading, reference, learning, consultation, and for communication with patients.

1. Introduction

Smartphones are phone devices that may also be used for browsing, navigation and running smaller computer programs called applications. One may consider them as compact personal computers which are primarily to be used for making phone calls. Several vendors offer similar devices, therefore smart phones can be categorized based on the mobile operating system that they run.

Tablets or "tablet PCs" are fully functioning standalone computers the size of a thin LCD monitor, which use the screen itself for control and data input. These devices may also be categorized based on the mobile operating system that they use.

Thus far, there are four main mobile operating systems: iOS [1], Android [2], Blackberry OS [3], and Windows Phone [4].

The iOS, which is a product of Apple, is run by the iPhone (smartphone), iPod Touch (media player and mini computer) and the iPad (tablet) exclusively. This is a closed and controlled system where each and every application must confirm to the rules set by Apple, though this also guarantees that one will find thousands of high-quality and safe applications on iTunes [5].

Android, a brainchild of Google, is a Linux-based, open source operating system that is run by a growing number of mobile phones, netbooks and tablets. The Android Market has been rapidly expanding, but as of now there are only a limited number of medical applications that may be relevant for diagnostic imaging.

Blackberry iOS runs solely on RIM's tablets and mobile phones, while Microsoft's Windows Phone is a unique operating system that is now also available on selected Nokia phones. The Blackberry App World, and Windows Phone Marketplace only offer a few applications of interest, but in the future their selection is expected to expand quickly.

2. Materials and methods

A search was performed on iTunes, Android Market, Blackberry App World, and Windows Phone Marketplace for mobile

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Applications for diagnostic reading.

1. eFilm Mobile (iOS – 9.99 USD)
https://www.merge.com/na/estore/efilmmobile/index.aspx
2. OsiriX (iOS – 29.99 USD)
http://www.osirix-viewer.com/Downloads.html
3. iClarity (iOS – 9.99 USD)
http://www.icrcompany.com/RSNA/iclarity.html
4. Mobile MIM (iOS – free)
http://www.mimsoftware.com/products/iphone
5. ResolutionMD (iOS – free)
http://www.calgaryscientific.com/index.php?id=5
6. CoActiv (iOS – 19.99 USD)
http://www.coactiv.com/press_releases.htm
7. ImageVis3D (iOS – free)
http://www.sci.utah.edu/cibc/software/41-imagevis3d.html
8. DICOM Droid (Android – free)
https://market.android.com/details?id=be.ac.ulb.lisa.idot.android.dicomviewer&feature=search_result
9. Centricity Radiology Mobile Access 2.0 (iOS – free)
http://itunes.apple.com/us/app/centricity-radiology-mobile/id501936750?mt=8
10. Siemens syngo® via WebViewer (iOS – free)
http://itunes.apple.com/us/app/siemens-syngo-.via-webviewer/id410836437?mt=8
11. iPaxera (iOS – 4.99 USD)
http://itunes.apple.com/us/app/ipaxera/id432861550?mt=8

Szekely et al., Eur J Radiol 2013;829-36

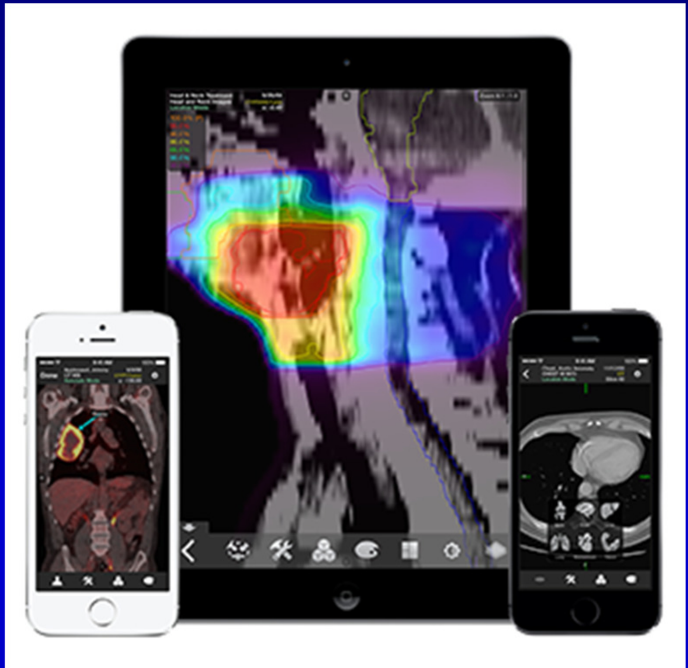
Cardiovascular Imaging on Mobile Devices. Is it Feasible?

7 Best FDA Approved Health Apps

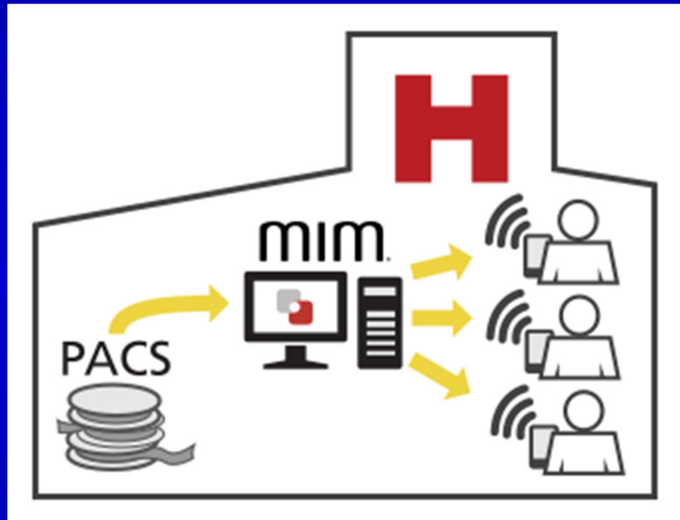
Mobile MIM

The first medical app ever to be included in iTunes stores, Mobile MIM is designed to share images from radiation oncology, radiology, nuclear medicine, neuroimaging and cardiac imaging. The health app is intended to enhance physician access to image scans to help them consult with peers on challenging cases, reduce image distribution delays, and share images with referring physicians, partner institutions, and patients.

Mobile MIM



Mobile visualization



Access to your patient data

http://www.mimsoftware.com/products/mobile/

ResolutionMD

Calgary Scientific Receives FDA Clearance for Mobile Diagnosis on all Modalities

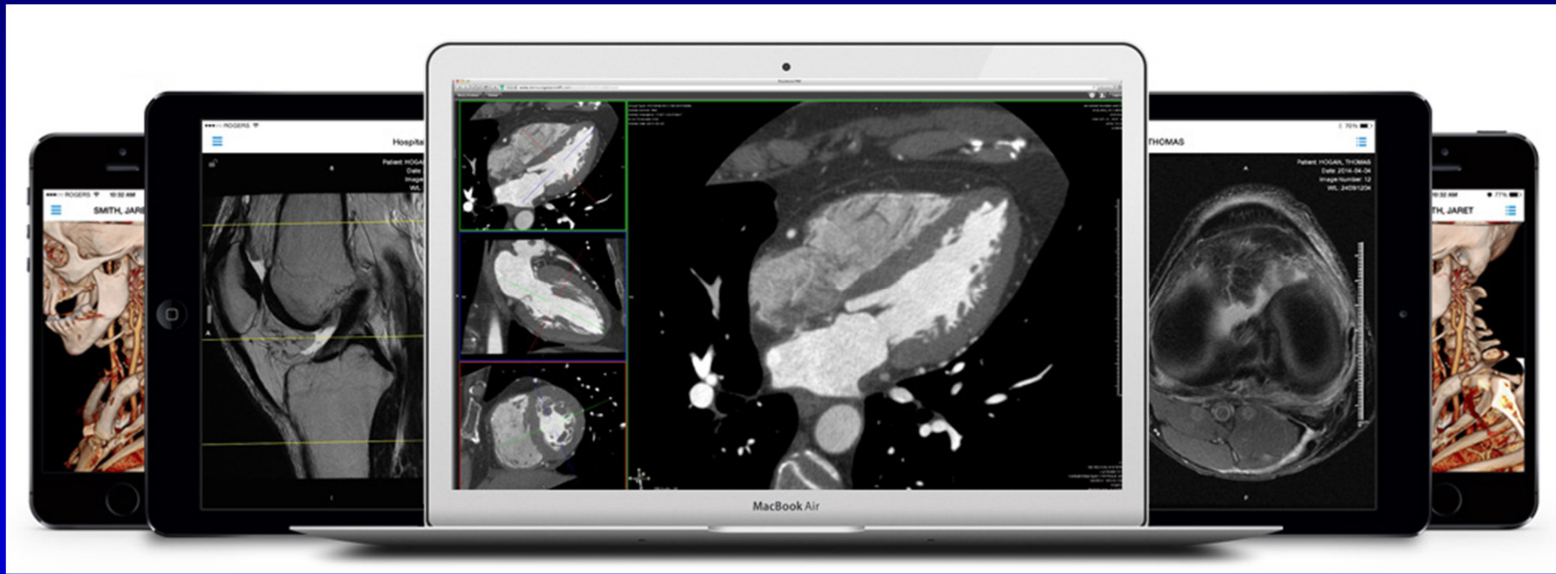
Posted on Apr 7, 2014 2:00:03 AM

Tweet 3 | in Share 52 | Like | Share 0 | g+1 0

Calgary, AB – April 7, 2014 – Calgary Scientific Inc., a company known for creating transformative technology for the medical industry and beyond, announced today their latest Class II clearance from the United States (US) Food and Drug Administration (FDA). The leading enterprise image-viewing solution, ResolutionMD® is now cleared for diagnosis on mobile devices, for all imaging modalities*. Calgary Scientific worked closely with a number of Radiologists at a world renowned healthcare organization to clinically validate the solution prior to submitting to the FDA. This builds upon their previous clearances for diagnosis using web, iOS and Android devices.

http://offers.calgaryscientific.com/resolutionmd4

ResolutionMD



ACCREDITATIONS

Accreditations for safe diagnosis from any web or mobile device

SECURITY

Server side rendering with data never being moved to any device

MOBILITY

Access medical images for diagnosis from any device

INTEROPERABILITY

Integrate with any EMR, PACS, VNA or other IT systems

http://offers.calgaryscientific.com/resolutionmd4

FDA Approval Classes I, II & III

<u>**FDA Guidance**</u>

The FDA regulates software and devices according to three classes. In Classes I and II, products can be released without FDA approval but are subject to scrutiny from the agency and can be taken off the market at its behest.
In Class III, on the other hand, products require pre-market approval.
"The FDA's initial response was that these apps should be subject to pre-market approval," Hirschorn said.

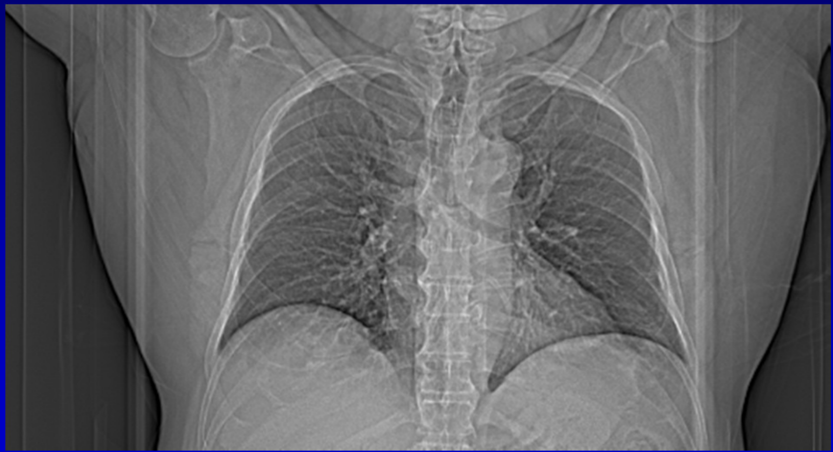
In July of 2011, the agency released a draft version of guidance on mobile medical apps. Regarding imaging apps, "They said they can pose risks".

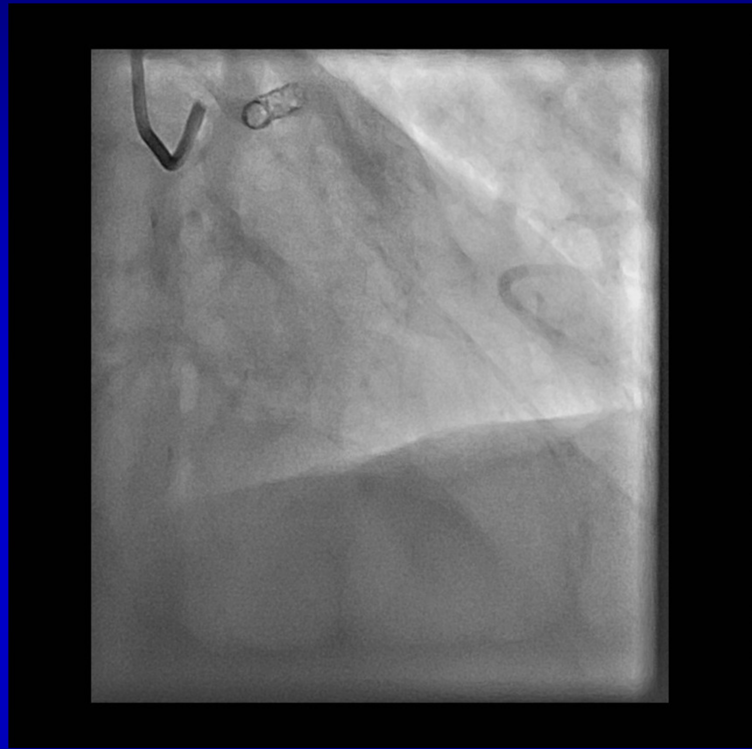
"*For example, interpretation of images could be adversely affected by smaller screen size, lower contrast ratio and uncontrolled ambient light. All of those things are very reasonable concerns.*"

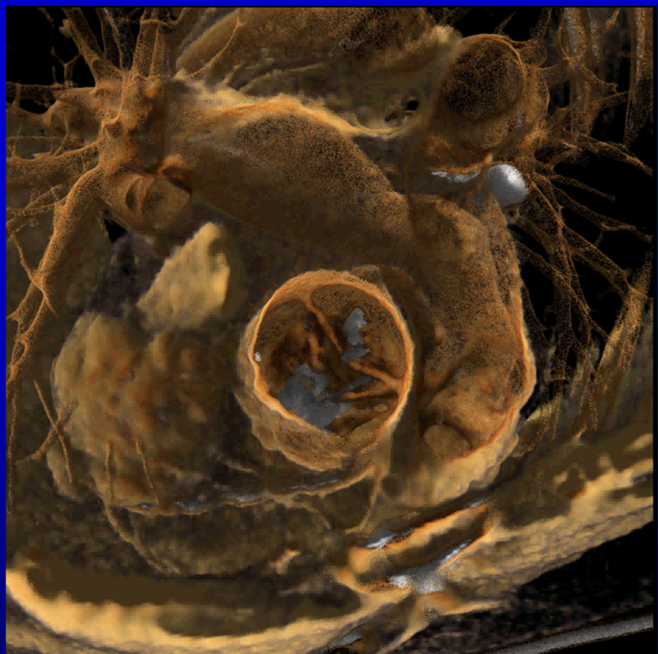
So Mobile Medical Imaging seems to be "Technically" Feasible and is Commercially Available

However, there are still many challenges, more especially within Cardiac Imaging amongst which "Clinical" Feasibility and Validation

Cardiac Imaging







Cardiology depends on dynamic imaging

Cardiac Imaging (MSCT) & Mobile Review

JACC: CARDIOVASCULAR IMAGING
VOL. 3, NO. 5, 2010

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER INC.
DOI:10.1016/j.jcmg.2009.11.018

CVN Interview

Diagnostic Accuracy of Coronary Computed Tomography Angiography as Interpreted on a Mobile Handheld Phone Device

Troy M. LaBounty, MD,* Robert J. Kim, MD,* Fay Y. Lin, MD, MA,* Matthew J. Budoff, MD,‡ Jonathan W. Weinsaft, MD,† James K. Min, MD†
New York, New York; and Torrance, California

OBJECTIVES This study assessed the diagnostic performance of coronary computed tomography angiography (CTA) for the detection and exclusion of significant coronary artery stenosis as remotely interpreted on a mobile handheld device with dedicated medical imaging software.

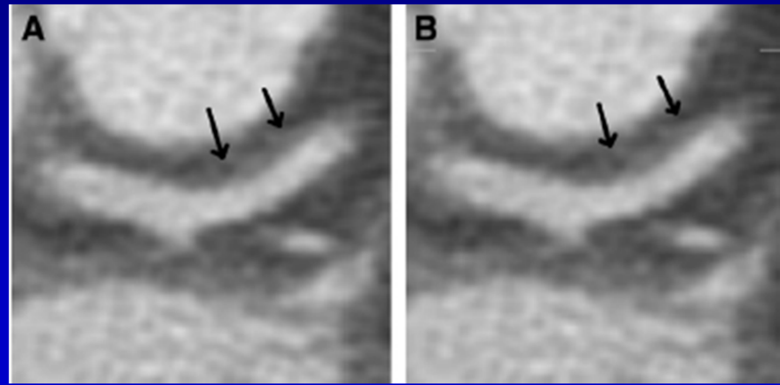
BACKGROUND Recent advances in technology now permit remote interpretation of medical imaging studies on mobile handheld devices, although the diagnostic performance of this approach is unknown.

METHODS We evaluated 102 patients with stable chest pain and both 64-detector row coronary CTA and quantitative invasive coronary angiography. The diagnostic performance of remote coronary CTA interpretation was assessed using a mobile handheld device and employing dedicated software. The coronary CTA studies were examined in an intent-to-diagnose manner for the presence or absence of coronary artery stenosis ≥50% on a per-artery and per-patient level; results were compared with quantitative invasive coronary angiography. Two blinded imagers independently interpreted coronary CTA studies, with a third imager achieving consensus for discordance. Coronary CTAs were re-interpreted in random order to determine interobserver agreement. Finally, coronary CTAs were evaluated on a dedicated 3-dimensional imaging workstation; results were compared to mobile handheld device findings for intertechnology agreement.

RESULTS The prevalence of significant coronary artery stenosis was 25% (26 of 102) at the per-patient level and 10% (40 of 405) at the per-artery level. Per-patient and per-artery sensitivity, specificity, and positive and negative predictive values were: 100% (26 of 26), 78% (59 of 76), 60% (26 of 43), and 100% (59 of 59), respectively; and 95% (38 of 40), 85% (310 of 365), 41% (38 of 93), and 99% (310 of 312), respectively. At the per-artery level, interobserver, intraobserver, and intertechnology agreement was 0.74, 0.89, and 0.75, respectively ($p < 0.01$ for all).

CONCLUSIONS The interpretation of coronary CTA using a mobile handheld device with dedicated software for medical image evaluation possesses high diagnostic accuracy for detection and exclusion of significant coronary stenosis. (J Am Coll Cardiol Img 2010;3:482–90) © 2010 by the American College of Cardiology Foundation

Workstation **Mobile**



The interpretation of coronary CTA using a mobile handheld device with dedicated software for medical image evaluation possesses high diagnostic accuracy for detection and exclusion of significant coronary stenosis.

LaBounty et al., JACC Card Imaging 2010;5(3):482-90

Cardiac Imaging (Echo) & Mobile Review

Interpretation of Remotely Downloaded Pocket-Size Cardiac Ultrasound Images on a Web-Enabled Smartphone: Validation Against Workstation Evaluation

Brian G. Choi, MD, MBA, Monica Mukherjee, MD, Praveen Dala, PhD, Heather A. Young, PhD, MPH, Cynthia M. Tracy, MD, Richard J. Katz, MD, and Jannet F. Lewis, MD, FASE, *Washington, District of Columbia; Camden, New Jersey*

Background: Pocket-size ultrasound has increased echocardiographic portability, but expert point-of-care interpretation may not be readily available. The aim of this study was to test the hypothesis that remote interpretation on a smartphone with dedicated medical imaging software can be as accurate as on a workstation.

Methods: Eighty-nine patients in a remote Honduran village underwent echocardiography by a nonexpert using a pocket-size ultrasound device. Images were sent for verification of point-of-care diagnosis to two expert echocardiographers in the United States reading on a workstation. Studies were then anonymized, randomly ordered, and reinterpreted on a smartphone with a dedicated, Health Insurance Portability and Accountability Act–compliant application. Point-of-care diagnosis was considered accurate if any abnormal finding was matched and categorized at the same level of severity (mild, moderate, or severe) by either expert interpretation.

Results: The mean age was 54 ± 23 years, and 57% of patients were women. The most common indications for echocardiography were arrhythmia (33%), cardiomyopathy (28%), and syncope (15%). Using the workstation, point-of-care diagnoses were changed in 38% of cases by expert overread (41% left ventricular function correction, 38% valvulopathy correction, 18% poor image quality). Expert interobserver agreement was excellent at 82%, with a Cohen's κ value of 0.82 (95% confidence interval, 0.70–0.94). Intraobserver agreement comparing interpretations on workstations and smartphones was 90%, with a Cohen's κ value of 0.86 (95% confidence interval, 0.76–0.97), signifying excellent intertechnology agreement.

Conclusions: Remote expert echocardiographic interpretation can provide backup support to point-of-care diagnosis by nonexperts when read on a dedicated smartphone-based application. Mobile-to-mobile consultation may improve access in previously inaccessible locations to accurate echocardiographic interpretation by experienced cardiologists. (J Am Soc Echocardiogr 2011;24:1325-30.)

Keywords: Echocardiography, Pocket-size ultrasound, Telemedicine

Pocket-size cardiac ultrasound (PCU) devices improve the portability of echocardiographic image acquisition.[1] In the hands of experienced operators, PCU has shown promising accuracy compared with traditional echocardiography.[2,3] However, without trained personnel capable of accurately interpreting the acquired information, the potential for misapplication or incorrect interpretation may hinder its adoption by clinicians.[1,2,4] Remote real-time expert echocardiographic interpretation has been demonstrated to be feasible, but such validation has required dedicated satellite connections and custom wireless transmitters,[5] which may limit its applicability outside the military setting. Remote interpretation with electronic transfer of data also brings concerns about breaches of the security of confidential patient information, of particular concern in the United States as the rules enforcing the Health Insurance Portability and Accountability Act (HIPAA) include civil penalties against physicians who transmit such data without reasonable safeguards against impermissible disclosure. We sought to develop a HIPAA-compliant, low-cost, mobile-to-mobile echocardiographic transmission system that would enable images to be acquired at remote locations previously inaccessible to ultrasound technology and allow expert echocardiographers to interpret studies remotely on smartphones. Such a system could provide expert interpretation to patients in isolated locations

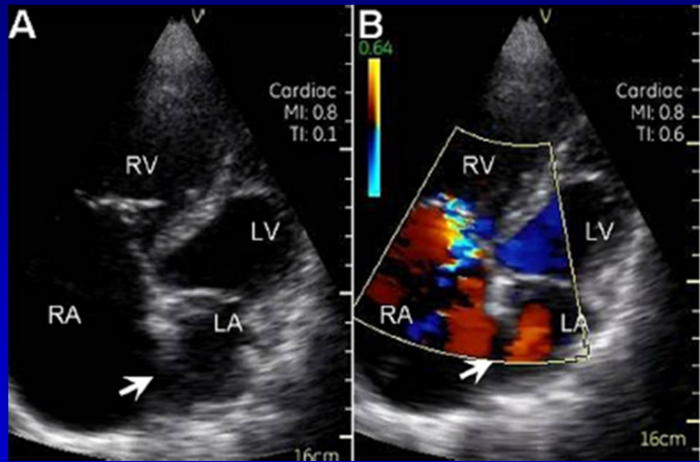
From the Division of Cardiology, Department of Medicine (B.G.C., M.M., C.M.T., R.J.K., J.F.L.), and the Department of Epidemiology and Biostatistics (H.A.Y.), The George Washington University, Washington, District of Columbia; and mVisum, Inc., Camden, New Jersey (P.D.).

The sole source of funding for this study was The Richard B. and Lynne V. Cheney Cardiovascular Institute, The George Washington University (Washington, DC). Dr. Dala is an employee of mVisum.

Reprint requests: Brian G. Choi, MD, MBA, The George Washington University, 2150 Pennsylvania Avenue, NW, Suite 4-417, Washington, DC 20037 (E-mail: *bchoi@mfa.gwu.edu*).

0894-7317/$36.00

doi:10.1016/j.echo.2011.08.007



Remote expert interpretation on smartphones may improve access to expert echocardiographic consultation. When paired with images acquired by a PCU device, the increased mobility in image acquisition and interpretation may markedly expand the use of echo in heretofore inaccessible clinical settings.

Choi et al., JASE 2011:1325-30

Short History of Image-Based Tele-Cardiology & Miniaturization

TeleCardiology

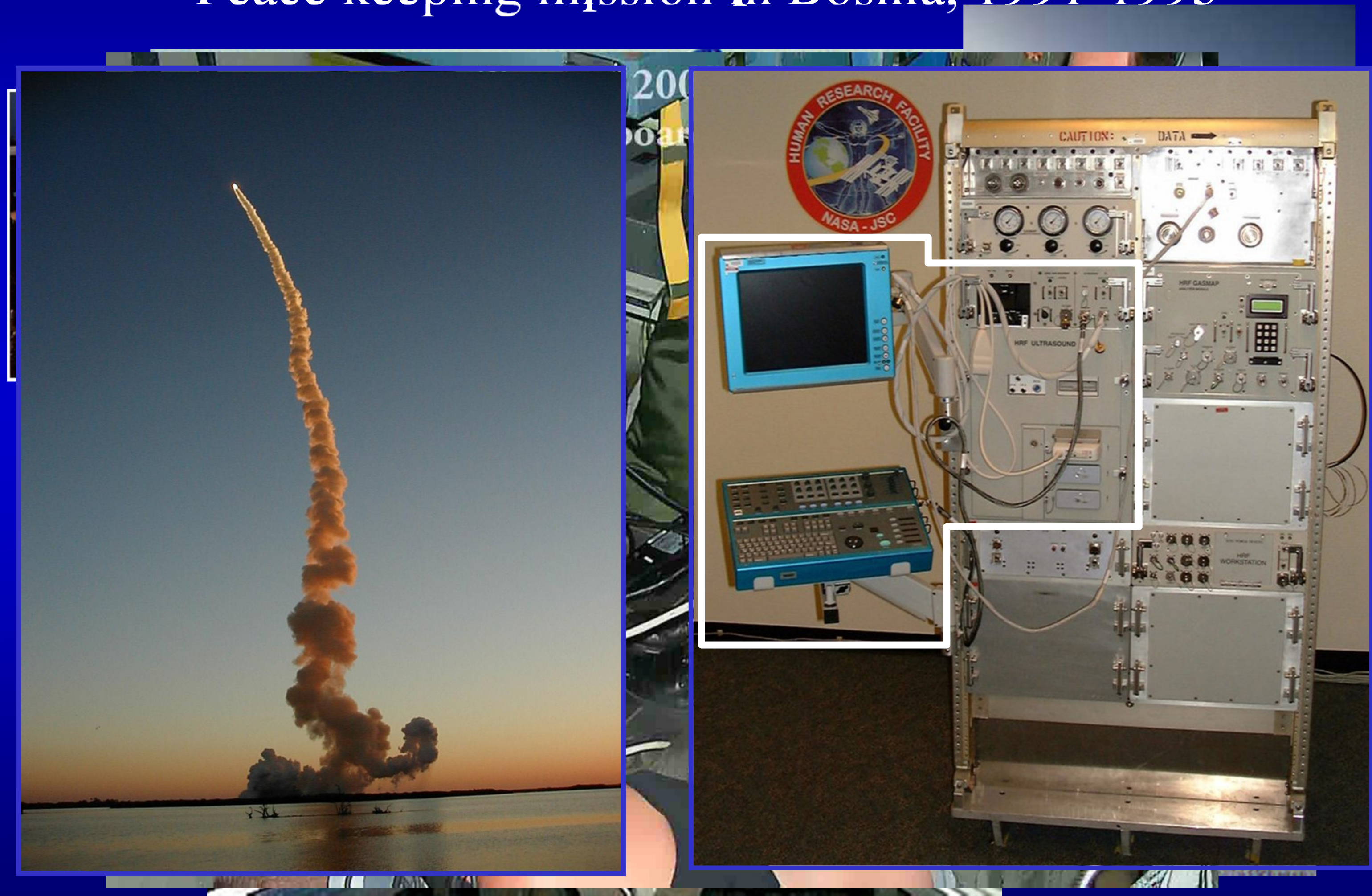
Ultrasound examination in an aircraft with Tetrason equipment,

First experiment by Willem Einthoven (1860-1927) in 1906, remote

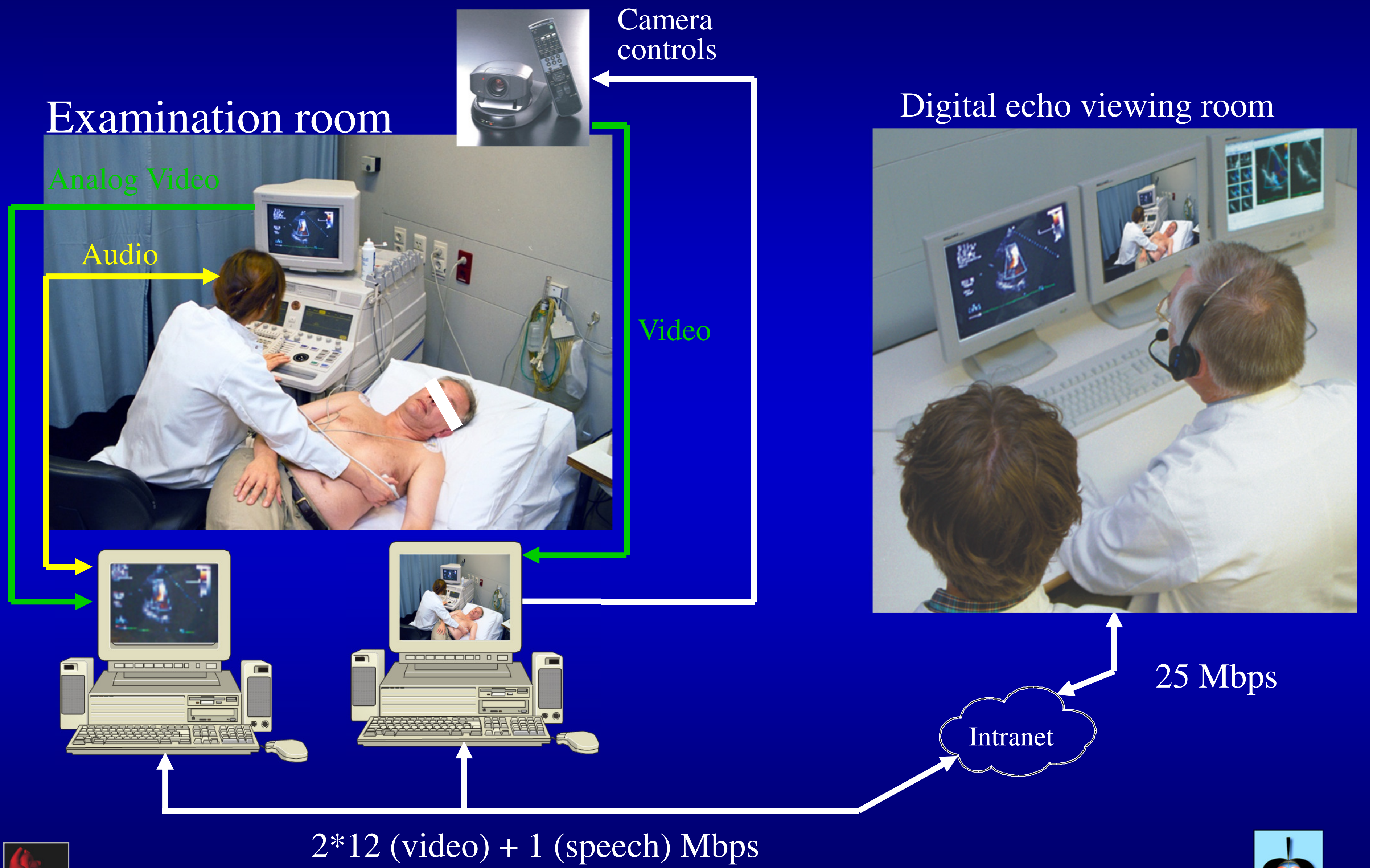
Launch of the Ultrasound System to the International Space Station

Ultrasound examination at the Mt Everest, May 1998

Peace keeping mission in Bosnia, 1991-1995



Tele-guiding echo examination



UltraSound TeleGuiding

"Live"
Examination

"Live"
Comment

Previous
Made ECG

"Live"
Ultrasound

TeleGuiding Equipment

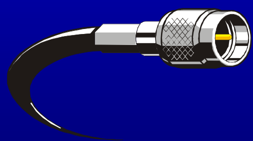
Remote Controlled Camera

Red Hat Linux OS

LML33 Framegrabber

Wireless Headset

Network Bandwidth 13 Mbps



RTPtv Software

Mobile Devices

Device Development Since 2007

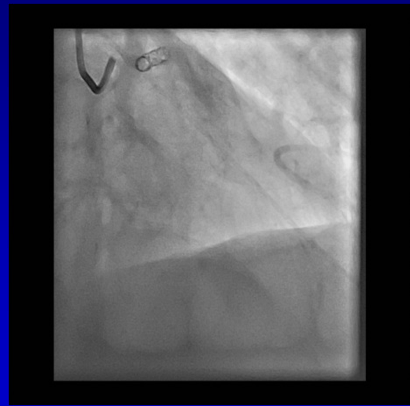
CATEGORY	iPhone 5	iPhone 4S	iPhone 4	iPhone 3GS	iPhone 3	iPhone
Resolution	1136 x 640; 326ppi	960 x 640; 326 ppi	960 x 640; 326 ppi	480 x 320; 163 ppi	480 x 320; 163 ppi	480 x 320; 163 ppi
Camera size (megapixels)	8	8	5	3	2	2
Video calling	FaceTime	FaceTime	FaceTime	none	none	none
Video recording	HD 1080p	HD 1080p	HD 720p	VGA	none	none
Battery life (talk time in hours)	Up to 8 on 3G	Up to 8 on 3G	Up to 7 on 3G	Up to 5 on 3G	Up to 5 on 3G	Up to 8 on 2G
Wireless carrier	AT&T, Verizon, Sprint, others	AT&T, Verizon, Sprint	AT&T, Verizon	AT&T	AT&T	Cingular (now part of AT&T)
Date released	Sept. 2012	Oct. 2011	June 2010	June 2009	July 2008	June 2007

When on a 4G network, the bandwidth of the network connection can be up to 50 Mbps

Mobile Devices & Cardiac Imaging

Screen resolution and network bandwidth might require some form of image sizing and perhaps even some compression

Bandwidth Calculation



Resolution	720 * 560 pixels
Sample depth	24 bits
Sample rate	25 frames/sec
Formula bitrate:	resolution * sample depth * sample rate
	722 * 560 * 24 * 25 = 242 Mbps

Formula compression: sampled bitrate / send bitrate

Example 12 Mbps : 240 / 12 = 20

Necessary Bandwidth's

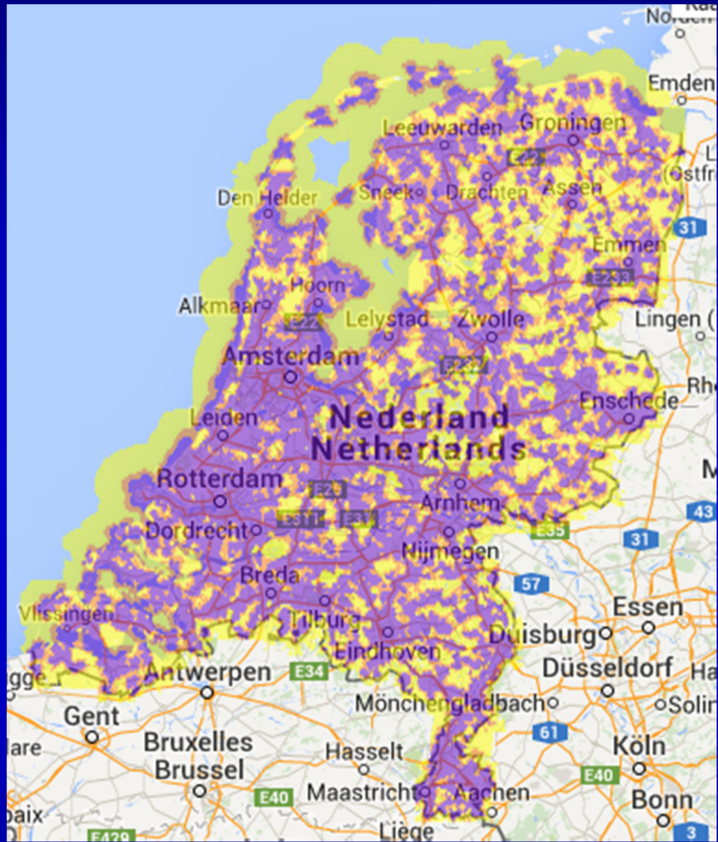
	Resolution	Images/s	Bandwidth	Quality
Low	352 * 288	25	4 Mbps	VHS tape
Medium	720 * 565	25	15 Mbps	Studio TV
High	1440 * 1152	25	60 Mbps	HDTV
Very High	1920 * 1152	25	80 Mbps	Film

Modern compression algorithms could be more efficient, such as H.264 and H.265. However, to my knowledge it has not been applied within medicine yet.

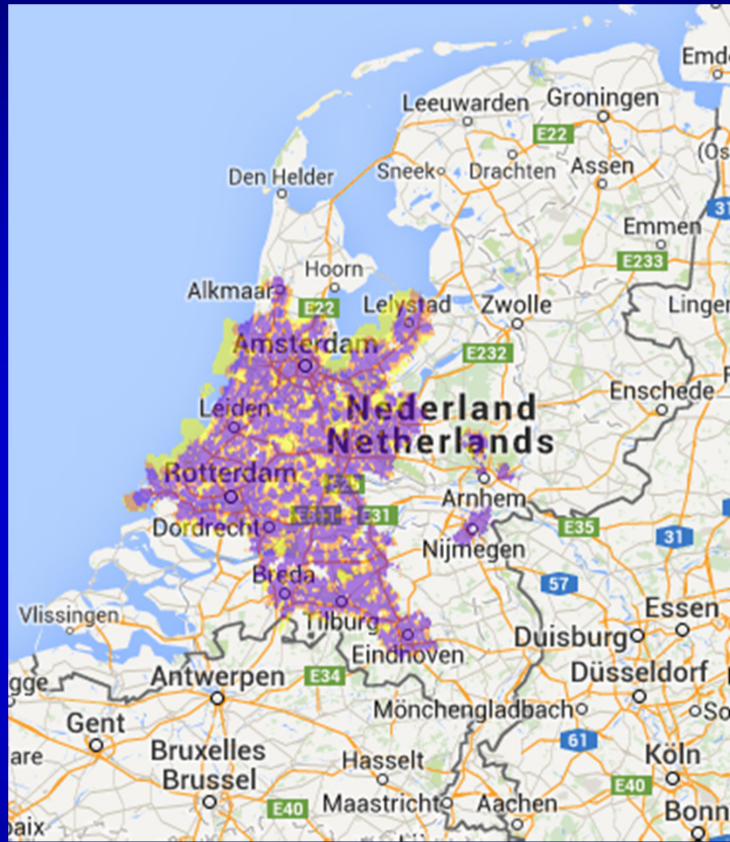
Mobile Network Coverage

Provider	Snelheid (max.)
kpn	25-50 Mbps
hi	25 Mbps
simyo	20 Mbps
Telfort	25 Mbps
vodafone	25-50 Mbps
T-Mobile	15-50 Mbps
MTV mobile	30-50 Mbps

Providers & Speed



3G



4G

Coverage for HD movie streaming

Imaging Group **Thoraxcenter**

Coronary Angiography and Compression

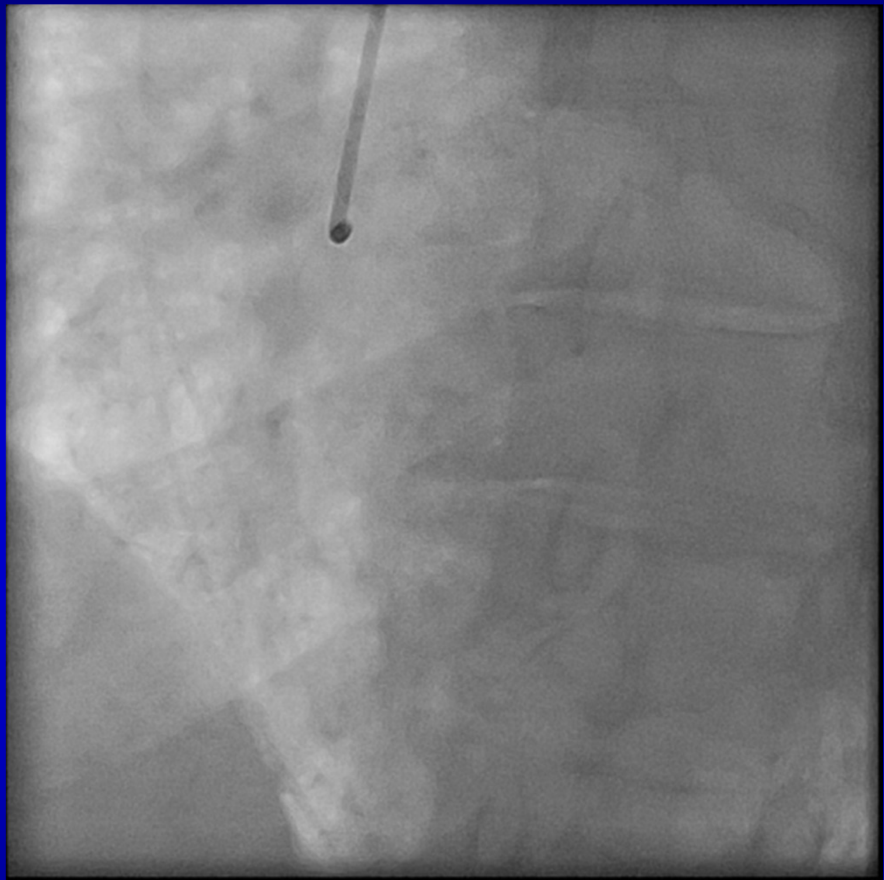


Image size in Adult Cardiology is mostly 1024*1024

Image size in our Pediatric Cathlabs is 2048*2048

The images are only uncompressed during the procedure

In which phase is remote/mobile assistance required?

Coronary Angiography and Compression

ELSEVIER

International Journal of Cardiology 60 (1997) 195–200

International Journal of cardiology

Impact of various compression rates on interpretation of digital coronary angiograms[1]

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Abstract

According to the ACC/ACR/NEMA/ESC-guidelines, digital techniques should be replaced by cinefilm for coronary angiography. The ad hoc group of experts recently chose CD-R (CD recordable) as transport media and the JPEG standard for image compression. To avoid a possible loss of image quality, the guidelines allow a maximal data compression of only 2:1. This, however, leads to a considerable limitation: coronary angiograms cannot be viewed in real-time directly from CD. Since the possible influence of higher compression rates on image quality of coronary angiograms had not been investigated in a controlled study, we evaluated 8 various compression rates (ranging from 5:1 to 43:1) according to a prospective, randomized and blinded protocol. Four independent observers assessed 1440 angiograms using a semiquantitative score. We found that angiograms with a compression rate of 5:1 and 6:1 did not lead to a clinically relevant deterioration of image quality, whereas 11:1 was still acceptable, but 43:1 becomes unacceptable. Since no clinically relevant loss of information at a compression rate of 6:1 was experienced in our study, a modification of the ACC/ACJ/NEMA/ESC-guidelines allowing higher compression rates should be considered. © 1997 Elsevier Science Ireland Ltd.

Keywords: cardiac catheterization; coronary artery disease; computer application; CD-ROM; ACC standard

1. Introduction

The advantages of the filmless cathlab are obvious: No use of chemistry and subsequent environmental protection, reduction of radiation exposure, simpler handling and finally, reduction of costs [1]. Therefore, replacing cinefilm by digital techniques is generally desired.

The ad hoc group of experts achieved a major task by establishing a general technical standard for digital archiving and interinstitutional exchange of coronary angiograms: the guidelines of the ACC (American College of Cardiology), ACR (American College of Radiology) and NEMA (National Electrical Manufacturers Association) [2]. The logical format is the in medicine well established DICOM 3.0-standard (Digital Imaging and Communications in Medicine). The physical format is the CD-R (compact disc-recordable). Its write-once-technique warrants a high degree of data security, using the industry standard of 'orange book' [3]. CD-R is faster and more robust than digital tapes like DAT, Exabyte or DLT. The capacity of a single CD-R with its 680 MB is sufficient to store 99% of cardiac catheterizations [2].

The technique chosen for data compression is JPEG (Joint Photographic Experts Group). However, the expert group recommended a maximal data compression of 2:1 (lossless compression), directly

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[1] Presented at the 45th meeting of the American College of Cardiology in Orlando, USA (ACC 1996).

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Journal of Digital Imaging

Lossy JPEG Compression in Quantitative Angiography: the Role of X-ray Quantum Noise

Johannes Peter Fritsch[1] and Rüdiger Brennecke[2]

In medical imaging, contrary to applications in the consumer market, the use of irreversible or lossy compression is still in its beginnings. This is due to the suspected risk of compromising the diagnostic content. Many studies have been performed, but it was not until 2008 that national activities in different countries resulted in recommendations for the safe use of irreversible image compression in clinical practice. Quantitative coronary angiography (QCA), however, poses a special problem, since here a large variation in published maximum compression factors has strengthened the general concerns about the use of lossy techniques. Up to now, the reason for the variation has not been thoroughly investigated. Reasons for the discrepancies in published compression factors are determined in this study. Since JPEG compression reduces the quantum noise of the X-ray images, the impact of compression is overestimated when interpreting any change in local diameter as an error. By taking into consideration the quantitative effect of quantum noise in QCA, it is shown that the influence of JPEG compression can be neglected for compression factors up to ten at clinically applicable X-ray doses. This limit is comparable to that found by visual analysis for aesthetic image quality. Future studies on image compression effects should take the interaction with quantum noise explicitly into consideration.

KEY WORDS: Image compression, angiography, coronary arteries, irreversible compression, quantitative coronary angiography, JPEG

INTRODUCTION

Irreversible compression facilitates the efficient storage and transmission of digital images. The application of irreversible compression was established early in the consumer market, boosting the development of technology and devices in this area. In medical imaging, however, the suspected risk of compromising the diagnostic content prevented the widespread application of irreversible compression for a long time. More precisely, two applications have to be distinguished: (1) the use of compressed images for routine visual assessment and (2) their use in quantitative evaluation. This study centers on the second application, but with regard to the aspect of image quality for medical applications, both have to be discussed in context.

Since the introduction of the first international standard for irreversible image data compression, JPEG, in 1992,[1] research has been intensified in both fields.[2] In 2000, Erickson concluded in a publication for the Society for Computer Applications in Radiology, "*Increasing evidence suggests that some forms of irreversible compression can be used with no measurable degradation in aesthetic or diagnostic value.*"[3] Six years later, in 2006, it was stated that "*based on scientific studies, irreversible compression is a clinically acceptable option for the compression of medical images,*" concluding, "*the adoption of irreversible compression as a standard of practice is no longer a matter of 'if' but a matter of 'when'.*"[4]

Following that, national activities were undertaken in different countries to establish the

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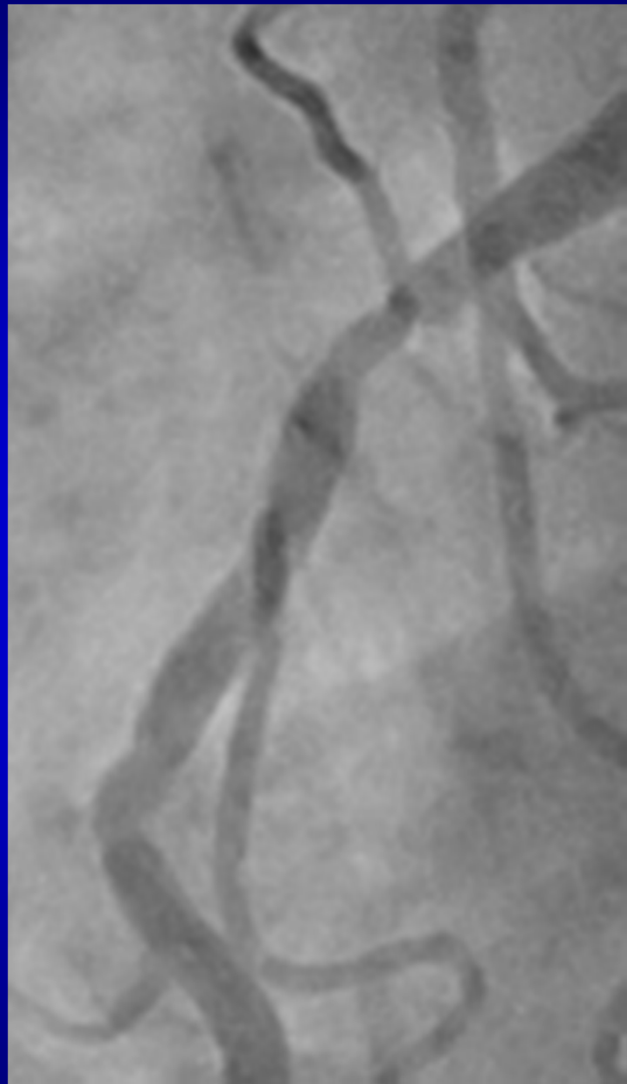
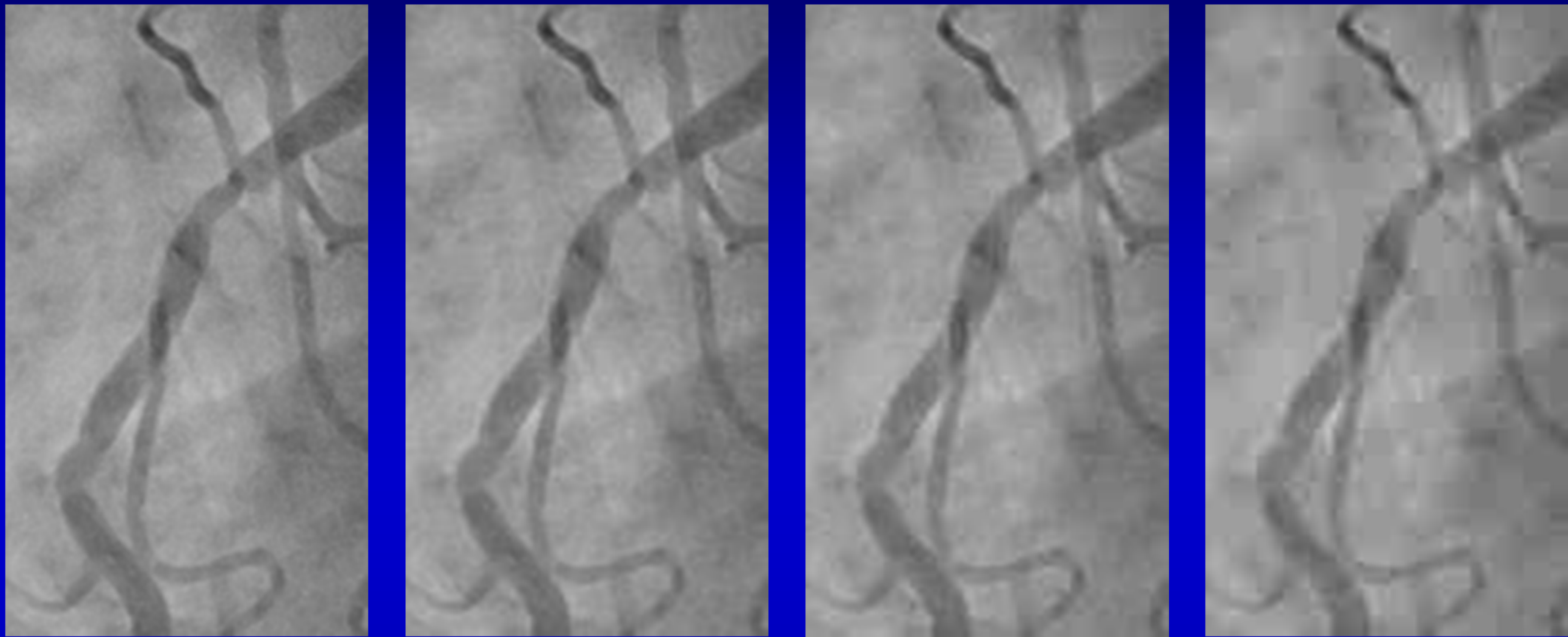
Coronary Angiography and Compression



Coronary Angiography and Compression



100% 80% 50% 20%

On first impression compression ratios up to 10:1 seem not to influence the "quality" of the images. However, tiny details might be lost and more research is necessary in clinical cases in which by example small intimal tears or calcifications are in play.

Challenges of Integrating Mobile devices Into Clinical Practice and Workflow

Some of the Challenges

- Integration in existing environment
- Who or what is responsible for storage and distribution?
- "Screen" Quality of reading devices
- Influence of environment were images are observed

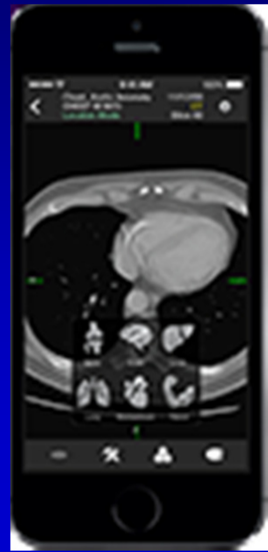
Image Intepretation on Mobile Devices

- Ambient Light
- Screen Brightness
- Careful Use
- Distractions
- Dirty Screen
- Viewing Angle
- State of Mind
- Screen Protectors

Mobile MIM Software

Image Intepretation on Mobile Devices

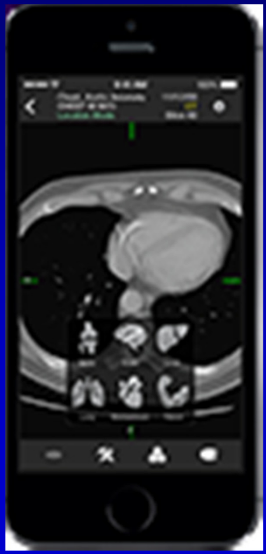
- Motion
- Bad Vision
- Shaky Hands
- Broken Screen
- Wireless Access
- Damage
- Battery
- Lack of Training



Mobile MIM Software

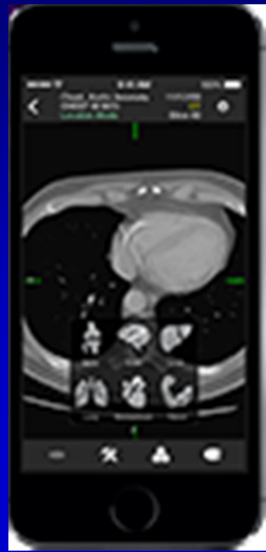
Image Intepretation on Mobile Devices

- Lack of Information
- New Hardware



Mobile MIM Software

Image Intepretation on Mobile Devices



- **Ambient Light**
- **Screen Brightness**
- **Viewing Angle**

Mobile MIM Software

DICOM Calibrated Viewing of Medical Images

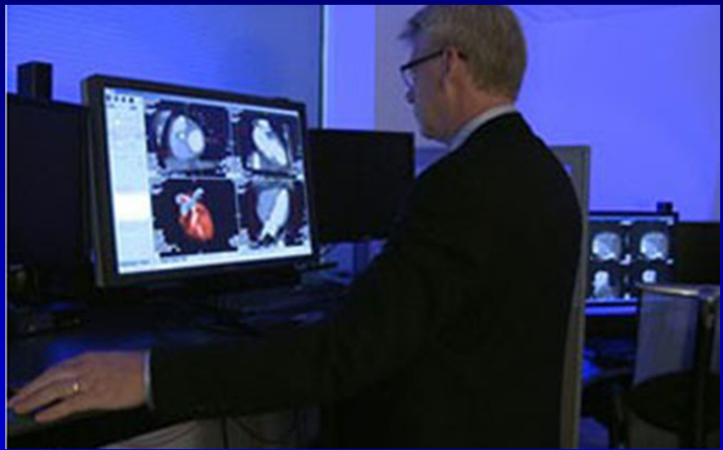
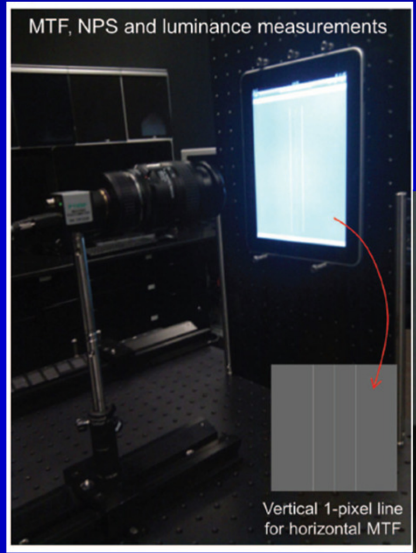
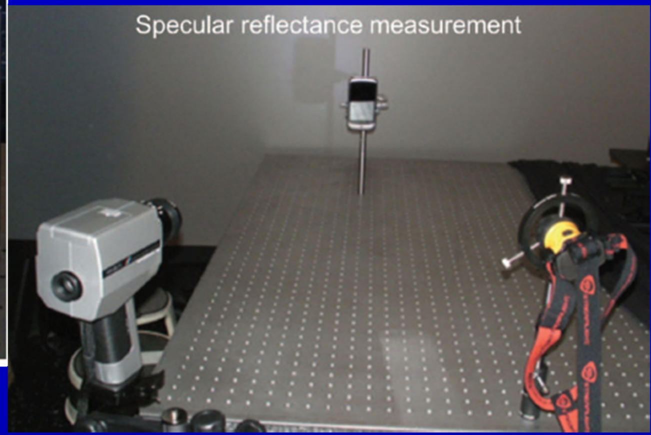


Image Quality Characteristics of Handheld Display Devices for Medical Imaging

Different mobile devices with different types of screen and sizes were tested in a professional setup

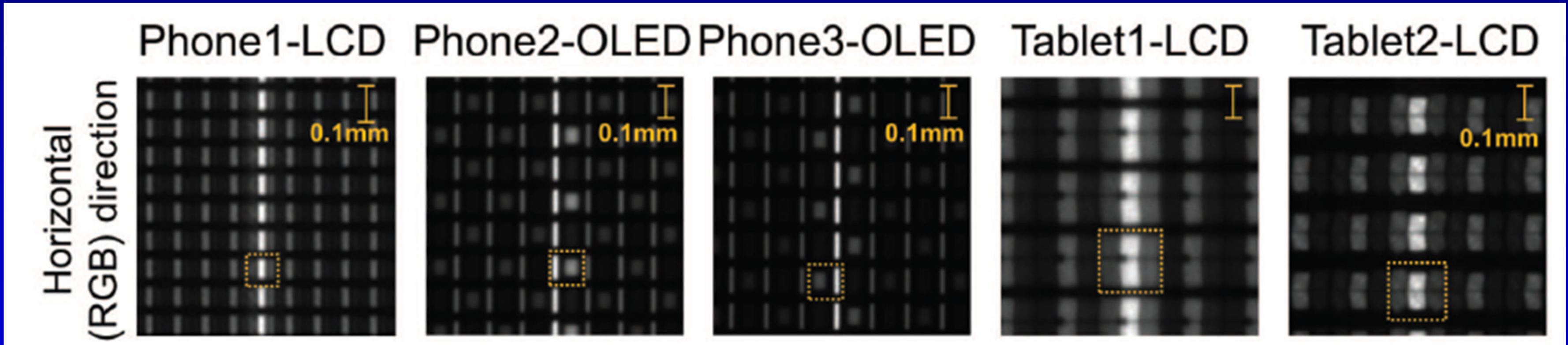




Display	Screen size (inch)	Pixel array	Pixel pitch (mm)
Phone1-LCD	3.5	640×960	0.0780
Phone2-OLED	3.7	480×800	0.101
Phon3-OLED	4.0	480×800	0.109
Tablet1-LCD	9.7	768×1024	0.192
Tablet2-LCD	10	800×1200	0.170
Tablet3-LCD	10	800×1200	0.170
Tablet4-LCD	7.0	800×1200	0.118
Tablet5-LCD	9.7	1536×2048	0.096
WS-5MPLCD	21	2048×2560	0.165
WS-3MPLCD	20	1536×2048	0.207

Yamazaki et al., PLOS one 2013;8(11):e79243

Image Quality Characteristics of Handheld Display Devices for Medical Imaging



We prove that handheld displays can have improved spatial resolution and noise characteristics compared to medical workstation displays particularly for recent hardware of the devices.

However, since the luminance characteristics of handheld displays do not comply with the Grayscale Standard Display Function (GDFS) response, the displayed image contrast is different from images radiologists and medical staff are familiar with viewing on their workstation displays.

Yamazaki et al., PLOS one 2013;8(11):e79243

The Effect of Ambient Light on Handheld Display Image Quality

	Device A	Device B
Manufacturer	Google/HTC	Samsung
Model	1*st* Gen	GT-I9000
Display	Normal TSP (AMOLED)	On-Cell TSP (SAMOLED)
Resolution	480×800	480×800
Pixel arrangement	PenTile	PenTile
Pixel density	252 ppi	233 ppi
Luminance range*	36,379	51,155
Minimum luminance*	0.0058 cd/m2	0.0058 cd/m2
Maximum luminance*	229 cd/m2	296 cd/m2

Handheld display devices for medical imaging exhibit characteristics that may in some circumstances significantly affect image quality. Users must be aware of the limitations when the screen is viewed under different ambient illuminations.

We show that handheld displays have relatively high reflectivity that varies with screen technology and causes glare in high illumination environments.

We also show that this high reflectivity leads to decreased detection performance using the DENOTE technique, a noise-embedded text detection task, for analysing which ambient illuminations are suitable for viewing medical images on handheld devices. We found that as illuminance increases, user performance for the detection task considered greatly decreases.

Liu et al., J Digit Imaging 2014;27:12-18

iPad Air 2 Diminished Reflectivity

The lowest reflectance of any tablet.

iPad Air 2 features a custom-designed antireflective coating that reduces glare by 56 percent, making it the least reflective tablet in the world. In virtually any kind of environment — offices, classrooms, outdoors — everything is clearer and more readable.

But one screen modification Apple did talk about was an anti-reflective coating. The company said this is something that hasn't been done on a tablet before, and will reduce reflections by 56 percent. Apple's glossy screens have historically tended to be on the reflective side, so this could be a nice (if unglamorous) upgrade.

THE Major Challenge =

Validation

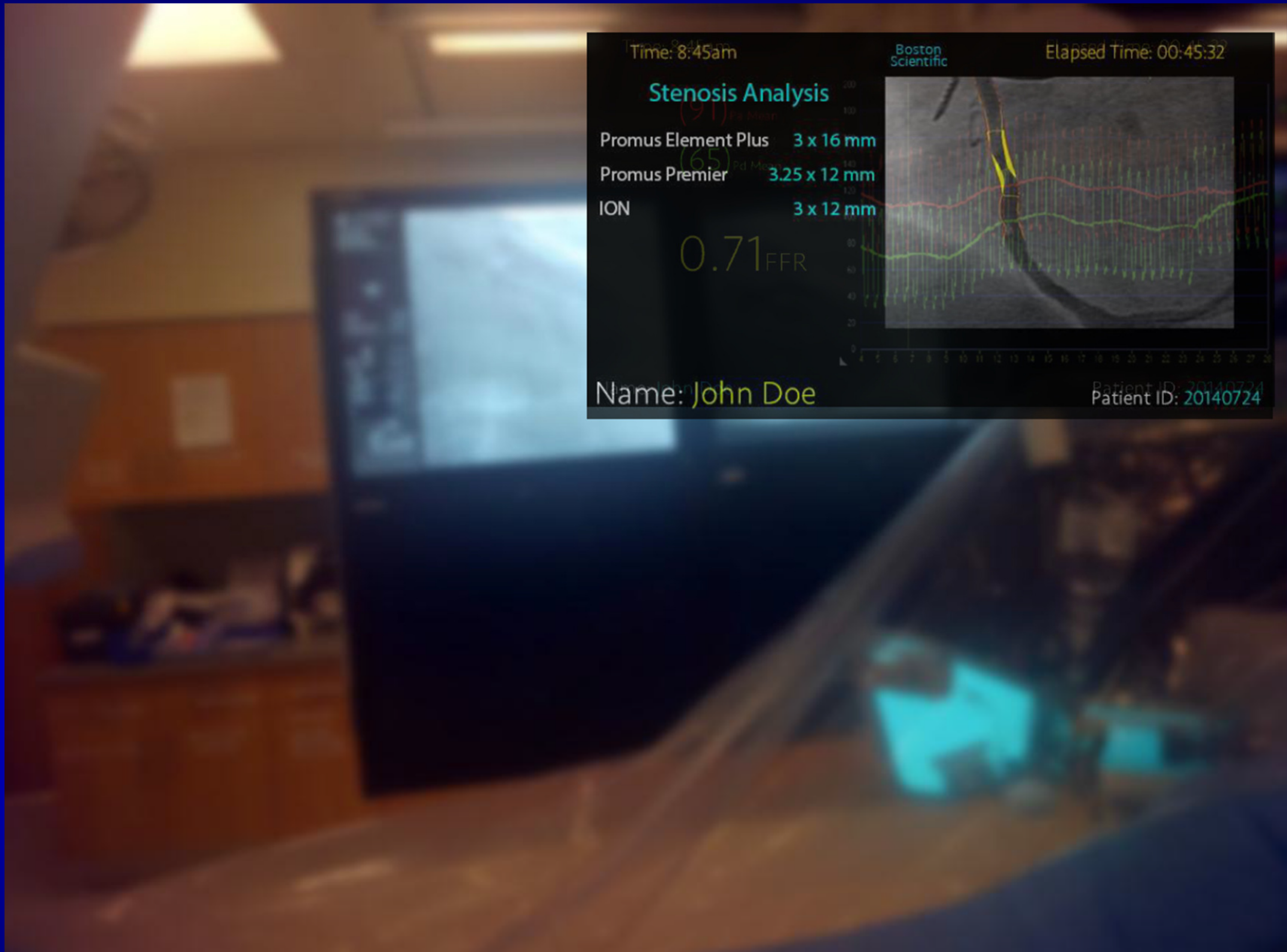
How to evaluate the diagnostic performance differences between images evaluated in the controlled hospital environment and those observed using a mobile device on the go?

A “Possible” Future Development Of Mobile Cardiovascular Imaging and Tools

Google Glass in the Cathlab

Dr. Safirstein J., @TCT 2014

Google Glass in the Cathlab



Dr. Safirstein J., @TCT 2014

Google Glass in the Cathlab

Dr. Safirstein J., @TCT 2014

Summary

Mobile devices have revolutionized the way we communicate and access data.

The high-speed communication networks and the quality of the mobile devices in processing speeds, storage capabilities and with respect to imaging, the excellent quality of the displays, has brought mobile medical imaging a major step closer to clinical practice, but there are still many challenges such as validation.

END