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Authors
Tobis, Jonathan
Aharonian, Vicken
Mansukhani, Prakash
et al.

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Video Networking of Cardiac Catheterization Laboratories

Jonathan Tobis, Vicken Aharonian, Prakash Mansukhani, Rair Jhandyala, Shunji Kasaoka, Rirei Son, Robert Browning, Linda Youngblood, and Mark Thompson

A video telecommunication network was established to transmit coronary images between a cardiac catheterization laboratory and a remote core laboratory. In 40 patients during interventional procedures, cine angiograms, live fluoroscopy, intravascular ultrasound studies, and images of the cath lab were transmitted in real time over a T1 line at 768 kbits/second at 15 frames/second. Results: Measurements of angiographic and intravascular ultrasound parameters were very close between the original studies and the transmitted images. The telecommunication link up during the interventional procedures had a significant affect in 58% of cases.

KEY WORDS: video telecommunications, angiography, intravascular ultrasound

THIS STUDY was performed to assess the feasibility and accuracy of a video communication network to transmit coronary images in real time through commercial telephone lines to permit interaction between personnel in a cardiac catheterization laboratory and a remote core laboratory.

METHODS

A point to point VTEL 225 BK telecommunication system (VTEL. Inc. Austin, TX) was installed in the core laboratory at the University of California, Irvine and connected with another VTEL 225 BK module 40 miles away in the cardiac catheterization laboratory at Kaiser Sunset Hospital, Los Angeles, CA. The VTEL system uses proprietary data compression algorithms to transmit data over telephone lines. The two laboratories were connected by a T1 phone line that can carry up to 24 channels. The VTEL system includes an IMUX (ASCEND multiband with T1-Primary Rate Interface) to convert the data to an acceptable format for the phone lines. This system allows video signals to be digitally converted, compressed, and sent at 768 Kbits per second using 12 of the telephone channels simultaneously. Images were transmitted at 15 frames per second.

CORE LABORATORY COMPUTER SYSTEM

In the core laboratory, the video images transmitted from the remote lab were passed through a video recorder (SVHS Panasonic Model 1960) and then serially sent to the digitizing board of an Apple Power PC 8500 computer. Selected frames of the coronary angiograms or intravascular ultrasound images were digitized at 640 × 480 pixels using software by AVID Video Shop 3.0.2 (Avid Technology, Tewksbury, MA). While the clinical case was in progress at the remote laboratory, measurements of lumen diameter from the angiograms or plaque and lumen cross-sectional areas from the ultrasound images were performed using public domain software (NIH Image v1.59). The images were analyzed using digital calipers with operator defined edge detection. The angiographic images were scaled using a 2× zoom mode and calibrated by the diameter of the guiding catheter. After an image was analyzed, it was moved to a second monitor attached to the computer. The output of the second monitor's video card was connected to the video input of the VTEL telecommunication system for transmission back to the remote laboratory. In this manner, the images originally downloaded from the remote laboratory could be measured and annotated by the core laboratory with the results of the quantitative measurements written on the image and transferred back to the laboratory for their review during the case.

DATA ANALYSIS

Following the catheterization procedure, the original videotape of the ultrasound images and the cineangiogram were mailed to the core laboratory. The original cineangiograms and ultrasound images obtained in the cardiac cath lab were compared with their corresponding paired images, downloaded over the telecommunications system at the time of the initial procedure. The sets of paired images were compared by linear regression analysis and the difference in measurements in the paired images were assessed by the Bland-Altman analysis.

RESULTS

Forty patients were randomized per protocol. There were no statistical differences in the clinical characteristics of the patients assigned to the angiographic versus intravascular ultrasound (IVUS) groups. The mean age of the patients was 59.8 ± 8.9 years; 32 (80%) of the patients were men. The baseline angiographic mean lesion length, mean minimum lumen diameter (MLD) pre- and post-stent, and the mean reference lumen angiographic diameters are shown in Table 1. There were no significant differences between the two groups for the baseline angiographic parameters. The final "punch-out" balloon mean diameter was 3.7 ± 0.4

From the University of California, Irvine, Medical Center, Division of Cardiology, Orange; Kaiser Permanente Medical Center, Los Angeles; and MTRW, Inc, San Clemente, CA.

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Address reprint requests to Jonathan M. Tobis, MD, UCI Medical Center, Division of Cardiology, 101 The City Dr, Bldg 53, Room 100, Orange, CA 92868-3298.

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Table 1. Angiographic Baseline Characteristics

	Angio Group	IVUS Group	*P*
Treated Vessel			
LAD	10 (50%)	7 (35%)	0.34
RCA	6 (30%)	8 (40%)	0.51
LCX	4 (20%)	3 (15%)	0.68
SVG	0	2 (10%)	0.15
Lesion Length	10.2 ± 3.8	11.5 ± 4.6	0.35
MLD Pre	0.8 ± 0.3	0.8 ± 0.2	0.63
MLD Post	3.2 ± 0.5	3.3 ± 0.6	0.63
Ref Prox	3.2 ± 0.6	3.3 ± 0.5	0.54
Ref Distal	3.1 ± 0.5	3.1 ± 0.8	0.84

Abbreviations: LAD, left anterior descending; LCX, left circumflex coronary artery; RCA, right coronary artery; SVG, saphenous vein graft.

mm and the mean final pressure was 17.4 ± 2.1 atm.

Telecommunications

The telecommunication network was successfully completed in 39 (98%) cases. The linkup was delayed in three (8%) cases due to routing problems within the phone company. The quality of the video images was impaired in one (3%) case due to "tileing" from inadequate speed of transmission when the T1 line was not used, and the quality of the audio was impaired in one (3%) case due to intermittent drop out of the voice channel from the cath Lab.

The results of the quantitative comparison between the original cineangiograms and the angiographic images digitized over the telecommunications network are shown in Table 2. There were no significant differences between the original cine and the telecommunications angiograms for the lesion length or the reference lumen diameter proximal or distal to the stent, both pre- and poststent insertion. The baseline MLD was 0.8 ± 0.3 mm for the original cine angiograms and was 0.7 ± 0.3 mm for the telecommunication group, $P < .008$. The correlation of angiographic minimum lumen diameter measurements between cineangiograms and telecommunication images was very close ($r = 0.99$, $Y = 0.97X - 0.04$). The Bland-Altman analysis for MLD pre- and poststent showed that the average difference in measurements was 0.1 ± 0.2 mm pretreatment and 0.1 ± 0.4 mm poststent insertion.

The results of the IVUS measurements comparing the original S-VHS tapes and the images digitized during the telecommunication study are shown in Table 3. There were no significant differences between these methods for assessment of lumen diameters or areas either within the stent or at the proximal or distal reference zones. The correlation coefficients between the original studies and the telecommunication system were between 0.93 and 0.99. The Bland-Altman analysis for stent area by IVUS showed only minor differences between the original ultrasound tape and the telecommunication images, (average difference = 0.0 ± 0.3 mm^2).

DISCUSSION

This is the first time, to our knowledge, that a telecommunication network has been used to transmit interventional procedures from a catheterization laboratory to a core laboratory. This study demonstrates that a video telecommunication network provides excellent image quality with accurate representation of angiographic anatomy and lesion severity. In addition, IVUS lumen and plaque geometry also correlated closely with the original images observed directly in the cath lab. The telecommunication images minimally underestimated the diameter of the stenoses compared with the original angiograms (0.7 ± 0.3 mm *v* 0.8 ± 0.3 mm), but this was not clinically significant.

The video telecommunication network had a

Table 2. Cine versus Telecommunication: Angiographic Measurements (N = 39)

	Cine	Telecom	Paired t-Test	r
Lesion Length	10.8 ± 4.2	10.8 ± 4.2	0.92	0.99
MLD Pre	0.8 ± 0.3	0.7 ± 0.3	0.008	0.67
MLD Post	3.3 ± 0.6	3.2 ± 0.6	0.07	0.77
Ref Pre Prox	3.3 ± 0.6	3.3 ± 0.6	0.56	0.82
Ref Post Prox	3.5 ± 0.5	3.5 ± 0.5	0.20	0.81
Ref Pre Dist	3.1 ± 0.7	3.1 ± 0.7	0.78	0.87
Ref Post Dist	3.3 ± 0.6	3.2 ± 0.7	0.15	0.83

Table 3. VCR versus Telecommunication: IVUS Measurements (N = 19)

	Tape	Telecom	Paired t-Test	r
Prox Ref Maj	4.2 ± 0.9	4.2 ± 0.9	0.25	0.98
Prox Ref Min	3.7 ± 0.9	3.6 ± 0.9	0.24	0.99
Prox Ref Area	12.8 ± 6.0	12.8 ± 6.0	0.70	0.99
Dist Ref Maj	3.6 ± 0.6	3.5 ± 0.7	0.11	0.93
Dist Ref Min	3.1 ± 0.5	3.0 ± 0.6	0.20	0.93
Dist Ref Area	9.5 ± 3.2	9.5 ± 3.2	0.31	0.99
Stent Maj	3.4 ± 0.5	3.4 ± 0.5	0.64	0.96
Stent Min	3.0 ± 0.4	2.9 ± 0.4	0.08	0.94
Stent Area	8.0 ± 2.0	8.1 ± 2.1	0.60	0.98

significant impact on the performance of 23 (58%) cases in this small clinical trial. The causes of this influence were (1) the presence of another reviewer for discussions of image interpretation or recommendations of technique on-line during the intervention, (2) the ability to have quantitative coronary angiography performed by an independent observer at the time of the procedure, and (3) the presence of an experienced reviewer of IVUS images both for diagnosis and measurement at the Core Lab. The implications of this initial study for the use of telecommunications in interventional procedures are significant. Telecommunication networks could be used to link community hospitals to universities or other centers of excellence to facilitate physician training and improve technical skills and judgement during interventional cases. This could also assist managed care networking to a tertiary center for review of cases for clinical conferences. Finally, this project demonstrates a paradigm of how future multicentered clinical trials could be operated through video telecommunication networks so that the procedures could be reviewed on-line for appropriate inclusion criteria, correct adherence to the protocol, and immediate assessment of the adequacy of the results.