

Desktop Echocardiography

N van der Putten, R Hamers, S Nelwan, W Vletter, F ten Cate, WA Dijk¹, MH Baljon²

Thoraxcentre, Erasmus MC, Rotterdam, The Netherlands; ¹University Hospital Groningen, The Netherlands; ²ICIN, Utrecht, The Netherlands

Abstract

A complete component-based echo department information system has been developed. This system integrates network data acquisition, database management of images and result data and report generation. The data communication, storage, retrieval and viewing of the images are conducted using the commercial CURAD software.[1] This software provides facilities for DICOM network communication with echocardiography devices of almost all major ultrasound companies.

Storage, reporting and retrieval of the echo result data is realized with a custom-built web-based system.

The archive of images and the archive of result data have been integrated. Our medical workstation Patient 98 facilitates the simultaneous presentation of the images and the resulting results on two screens.[2] This offers hospital-wide access to echo images and results (and all other patient oriented data) without the necessity of proprietary hardware or software solutions.

Every clinician is capable to review echocardiographic images and reports on the PC screen on his desk (desktop Echocardiography).

1. Introduction

The Thoraxcentre in Rotterdam is a joint institute of cardiology and cardiac surgery at the Erasmus Medical Centre. The echocardiographic devices currently in use are the Acuson Sequioa and Cypress, the GE-Vingmed, the HP Sonos 5500 and the Toshiba Power Vision Systems. Echocardiographic studies are performed at the Echocardiographic Laboratory (in the Outpatient Clinic), the Cardiothoracic Operation Rooms, the IC's and in the wards.

Until 1998 the echocardiographic images in the Thoraxcentre have been primarily archived onto videotape, 3 1/2-inch and 5 1/4-inch magneto-optical disks and some local commercial echo-systems (Enconcert and Echopac). The echocardiographic images were only used for the primary diagnosis. Review of the images was too time-consuming.

In 1998 we started with limiting digital storage of echocardiographic images on a central server. Although the DICOM standard was already generally accepted as the standard for interchange and storage of echocardiographic images in that time, only a few ultrasound devices were able to push echocardiographic loops and all ancillary data like patient ID, study date, image calibration, velocity and turbulence information to a general DICOM server.

The major vendors offered solutions of fast storage of large amounts of high quality image loops and ancillary data in a vendor-specific format to media in company own repositories.

CURAD (Wijk bij Duurstede, NL) has developed an easy to use image archiving system in cooperation with the Thoraxcentre. This system allows simultaneous selection and hospital-wide review of DICOM cardiac ultrasound studies acquired on five commercially available scanners with the use of inexpensive PC's and software.[1]

The server is capable to store a large amount of DICOM images and ancillary data, to automatically convert non-DICOM images (Philips-HP, GE-Vingmed, Toshiba) to the DICOM format and to share these images as DICOM file on a local network.

Export of the digital images to the central server was realized by transfer to media like MOD or CD-R or via a network communication protocol.

In 2000 we decided to move gradually to a standard network-based DICOM exchange of echocardiographic images. A network-based information

system was set up interconnecting 5 of our 6 echo machines to the CURAD server. Examinations from the echocardiographs in the main echolab, the operation rooms, the wards and the intervention laboratories are connected to the server.

An echo result information system has been developed simultaneously. This web based system facilitates the input, storage and reporting of all echo results.

The following paragraphs describe the design, the implementation and the experiences with this complete component based echo department system.

2. Methods

2.1. Image acquisition, storage and review

The image server is connecting echocardiographs from Acuson, GE-Vingmed and Philips-HP. Unfortunately our (non-contemporary) Toshiba Power Vision was not capable to interchange echocardiographic loops in DICOM format. Software and hardware upgrades were required for the Sonos 5500 and the GE-Vingmed. The current system and infrastructure may collect DICOM echo images through the network from 5 of our 6 echocardiographs to the CURAD server.

Examinations from the echocardiographs in the main echolab, the OR's, the wards and the intervention rooms are connected to the server. The user is able to transfer images from the server to the Enconcert system for detailed analysis of the images (see fig. 1).

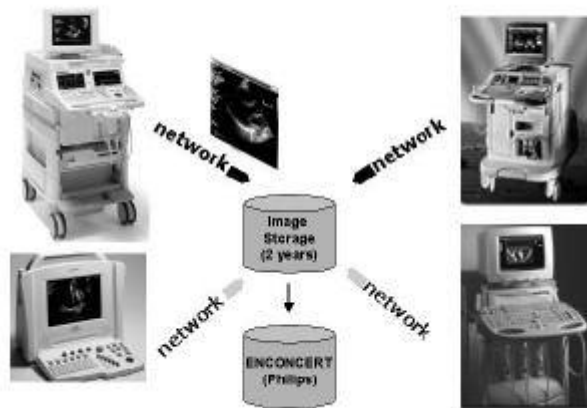


Figure 1: network based connection between echocardiographs and server.

These echocardiographs do not have a fixed location. They can be moved e.g. from the OR's, to the intervention rooms or the intensive cares. Reconfiguration is not necessary. The transfer of the images requires only the connecting of the echocardiograph to a network point. Our hospital provides mainly 10 BT transfer.

The echocardiographs can be configured to store loops containing single or multiple cardiac cycles as well as loops of fixed duration. The number of cardiac cycles and the duration of the loops are very dependent of the cardiograph brand. In our case the Sequioa has a much higher upper limit (60 seconds) than the other cardiographs (typically 10 seconds).

The primary review stations in our main echolab room are connected to the network with dedicated 100 BT lines, which are not connected to the hospital network). This facilitates fast access to the server. This fast access is also guaranteed, even if the network is slow or down.

The server (CURAD NV, Wijk bij Duurstede, NL) is capable to store a large amount of DICOM images and ancillary data. Currently the server has a capacity of 400 GB of local RAID storage; pre-estimated about two year online storage.

2.2. Echo result information system

A webbased system for the storage, reporting and retrieval of the echo result data (measurements, calculations and interpretations) has been developed using a 3-tier model, PHP, XML, and SQL-server. The design of this system had to face to its daily use, focusing on the real work of the sonographers.

The database was designed as a comprehensive archive that should provide detailed information about:

- The patient
- Logistic aspects for each study
- Quantitative and semi-quantitative measurements and derived parameters

The system consists of 4 modules:

- TTE routine echo
- TTE congenital echo
- TEE
- Stress echo

Facilities for the interoperability between this custom result database and the Enconcert database (Philips/HP) and the Echopac database (GE-Vingmed) are in progress (see fig. 2)

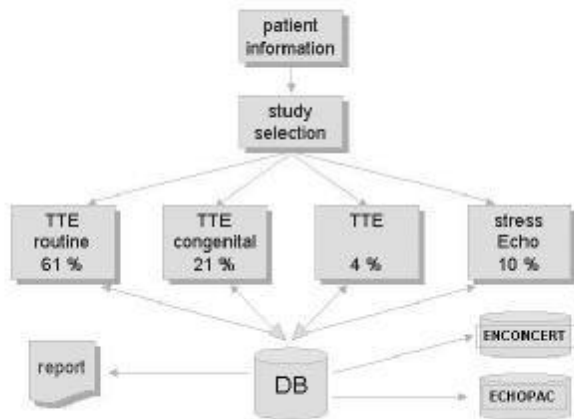


Figure 2: schematic overview of the echo information system.

The report generation is very flexible. It is XML based. The system facilitates options like:

- Graphical representation of the values of selected parameters (e.g. the ejection fraction) of subsequent examinations.
- Referral reason related reporting : “answer only the question posed by the referring physician”

2.3. Hospital wide access

The archive of images and the archive of result data have been integrated in our medical workstation Patient 98. The system has been developed as part of a larger effort that attempts to provide medical data processing for the common diagnostic and therapeutic procedures in cardiology within the framework of a general medical workstation. This workstation must give the clinicians transparent access to multi-modal data (the complete medical status of a patient including waveforms and images like echocardiograms and angiograms). Patient 98 is a modular patient-based system. New modalities can easily be plugged in.

Patient98 facilitates the simultaneous presentation of the images and the resulting results on two screens (see fig. 3). This offers hospital-wide access to echo images and results (and all other patient oriented data) without the necessity of proprietary hardware or software solutions.

Every clinician is capable to review echocardiographic images and reports on the PC screen on his desk (desktop Echocardiography).

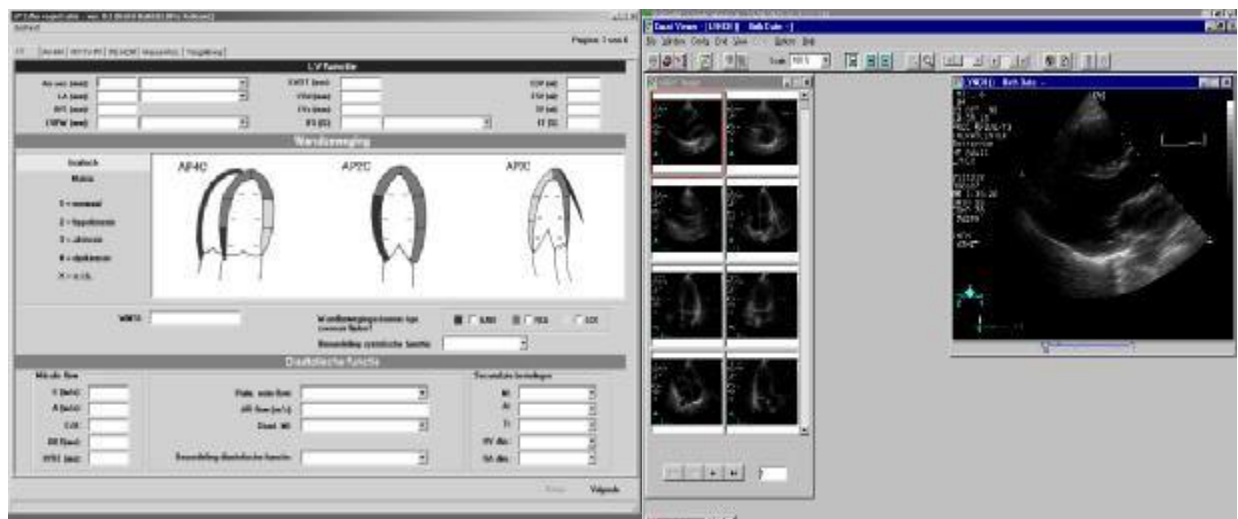


Figure 3 : simultaneous presentation of the images and the relating results.

3. Results

Only a minor part (about 30%) of the echocardiographic images have been transferred through the network to the server during the last 1.5 years. The main reason for this was the time involved with the upgrading of the Sonos 5500 and the GE-Vingmed to enable DICOM image network transfer. The education of the sonographers in digital recording of the echo images took only a short while. Presently about 70% of the echo examinations are archived in digital format. The system is appreciated very much. The image quality of the digital images is high. Review of echo images and related reports is now possible on every PC in the hospital. Subsequent examinations of one patient may be compared.

Average echocardiographic examinations require about 27 MB of RAID storage. In our echo laboratory that performs 7,000 studies yearly, our expected yearly volume of DICOM studies stored digitally will be nearly 200 GB of data.

The transfer time from echocardiographs through the network to the server is partly echo machine specific. Study rates for the Sonos 5500 and Acuson was in the order of 0.5 MB/sec. This result is very similar to the results of Greenberg[3].

The GE-Vingmed showed slower transfer times. This machine may operate in two modes :

1. Each clip is stored on disk (Echopac environment) and converted there to a DICOM file. The files are transferred with an average transfer time of about 0.5 MB/sec.
2. Each clip is converted and compressed to a DICOM file in internal memory and directly transferred to the server. The transfer is much slower

We are making use of the second mode with a transfer time of about 0.1 MB/sec.

Average access time to retrieve a study from the CURAD server is typically 2 to 15 seconds.

4. Discussion

Modern echocardiography equipment is capable to archive the measurements and derived parameters (e.g. fractional shortening) in digital format during the investigation; unfortunately not in the DICOM image files, but in vendor specific files. An automated digital exchange of measurements and derived parameters in a multi-vendor environment

requires vendor-specific software modules and protocols. We are still hoping on an extension of the DICOM standard with at least the standard measurements.

The echo result information system uses a proprietary data set with disadvantages like:

- 1) The comparison of serial echocardiograms performed at different sites is complicated.
- 2) Multicenter research, analyses of cost-effectiveness and the communication between different hospitals are difficult.

The development of a standardized component for the storage of the echocardiographic core result data and the generation of the echocardiographic report has been started. This project is a part of the EPDCAR project [4].

This standard component will be based on the in this paper described component for storage, reporting and retrieval of echocardiography result data.

References

- [1] Gerritsen M, Putten N van der, Dijk W, Dassen W, Spruijt H, Spruijt E, Uijen G, Hamers R. General DICOM Pacs Server for Echocardiography Images. In : Computers in Cardiology 1999; IEEE Computer Society Press, 1999; 431-434..
- [2] Putten N van der, Nelwan S, Meij S, Smits F, Slingerland M, Suling R, Kroon F, Baljon. Patient98: A Component Based Multimedia Workstation for Cardiac Care and Research. In : Computers in Cardiology 1999 ; IEEE Computer Society Press, 1999; 77-81.
- [3] Greenberg N, Castro P, Firstenberg M, Garcia M, Thomas J. Digital Echocardiographic Communication Using Multivendor Networked DICOM Devices. In : Computers in Cardiology 2000; IEEE Computer Society Press, 2000; 279-282.
- [4] <http://www.icin.knaw.nl/projectsprogresssict.html>.

Address for correspondence:

Niek van der Putten, PhD
Erasmus MC
Thoraxcentre
Dr. Molewaterplein 40
3015 GD Rotterdam
The Netherlands
E-mail: vanderputten@thch.azr.nl