Reviews

The Role of the Digital Computer in Pediatric Cardiology*

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Abstract. A digital computer system is described which allows the real-time processing of all physiological signals obtained during a heart catheterization procedure and which makes all relevant results and informations available immediately during the investigation.

In addition, special electronic units and programs have been developed in our institution for the automated extraction of morphological criteria from biplane angiocardiograms. Thereby right and left ventricular volume, shape and contraction pattern can be quantitated and used to characterize the performance of the heart as muscle and pump in physical terms.

Recently, complete digital processing of videoangiograms has been achieved in a stroboscopic mode, each videofield in real time. Application of image enhancement, subtraction, integration and restoration techniques leads to a fundamentally improved angiocardiographic image quality for a given amount of injected contrast material.

Based on eight years of experience with digital computer application in pediatric cardiology, computer technologies are considered likely to become the method of choice in the future.

Key words: Heart catheterization – Angiocardiography – Computers in cardiology – Videometry – Digital image processing.

Introduction

Diagnosis and therapy in pediatric cardiology is based on a careful history and clinical investigation in the same way as in other medical disciplines. But it is probably more dependent on additional data which can be only obtained by sophisticated technologies.

This is in particular true for the diagnosis of complex congenital malformations of the heart and circulation.

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Besides standard x-ray pictures, electro- and phonocardiography and recently introduced echocardiography, the final and quantitative diagnosis in congenital heart disease nearly always requires the performance of heart catheterization and angiography.

The data thus obtained can be divided into two major categories:

a) physiological data, such as intravascular and intracardiac pressures, along with the ECG, oxygen saturation and/or indicator concentrations and

b) morphological data, extracted from angiograms for analysis of the size, shape and contraction pattern of the cardiovascular structures.

Although most of this data can be obtained by conventional analog techniques, digital data processing by computers for both physiological and morphological criteria has several fundamental advantages, and it will probably be only a matter of time until more and more cardiology centers process their data in a more or less automated way by digital means. This technological development started in our institution about eight years ago. The objective of this article is to give a brief review of the present stage of computer techniques for processing heart catheterization and angiographic data, as achieved during recent years in our laboratories. The important fields of automated ECG analysis and computerized intensive care are not dealt with in this article.

The system to be described was initially designed for the acquisition, processing, display and reporting of all the data and information which are needed in the heart catheterization laboratory [8]. Hardware and software have been expanded to handle an increasing number of morphological parameters extracted from video-angiograms for quantitation of the volume, shape and contraction pattern of the heart chambers [9, 13, 16, 17, 19]. The most recent step in the development enables the complete digitization of serial angiographic images for further computer processing [1, 2].

This technique leads to a completely new type of "digital" angiography with a fundamentally improved image quality by image enhancement and restoration techniques.

The specific hardware and computer interface which allows the data transfer to and from the computer has been developed as an research effort from our bioengineering group.

The reader who does not wish to read the whole paper is invited to consider figure 4 which gives an impression of the potential functions and usefulness of these new techniques.

2. Computer Installation

The present hardware configuration is demonstrated in Figure 1 and consists of two central processing units (CPU): a Control Data 1700 computer and a Digital Equipment PDP 11/40 machine. The first installation (CDC 1700) has been primarily used for automated heart catheterization and ventricular volume determination. Also many other programs i.e. for ECG analysis, plot and statistical routines, as well as for ventricular shape and contraction pattern analysis, and finally for digital image processing have been written partly in assembler language and partly in Fortran for the CDC 1700.