A COMPUTER-BASED SYSTEM FOR MEASUREMENTS AND ANALYSES IN RADIOLOGY

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Abstract

A computer-based system for direct measurements on images and for analyses of data is presented. Distances, angles, and areas are measured on a backlighted digitizer table. Calibration corrects for actual magnification. Data are analyzed and compared to normal values by a microcomputer. The system is precise and time saving.

Key words: Computers; measurements.

In radiology measurements, calculations and comparison with normal values are important. With few exceptions (10) such procedures are performed manually. We have developed and since 1981 used a computer program for measurements, computations, and analyses. The aim of this study was to present the computer program, to test the precision of basic measurements, and to examine if the computer program had any time-saving effect compared to conventional measurements.

Method

An IBM-compatible microcomputer connected to a Hipad digitizer table (Houston Instruments) is used. The bottom plate of the digitizer is removed to permit backlighting. A cross-hair aim with a magnifying glass is used to locate coordinates for measurement of distances and angles or drawing of areas.

The program, initially written in BASIC, is re-written in TURBOPASCAL and continually revised and enlarged. Input data from the digitizer and keyboard are requested on the screen. The functions are selected from a menu.

1) Help function contains a detailed description of the program including references and technical data. 2) Basic measurements of distances, angles, areas and calibration function. 3) Computation of ventricular index, CAFFEY's index (1), bladder volume (6), and femoral anteversion (8). 4) Programs for organ measurements and comparison with normal values for kidney length (4, 5) and area (2), heart volume (3), and uterus size (9). 5) Calculation of difference between chronological and skeletal age and prognosis of final length based on date of birth and skeletal age (7).

The error of the basic measurements was evaluated by 20 replicated measurements of known distances (0 and 100 mm), angles (0 and 90°), and areas (100 cm^2) plotted on millimeter graph paper.

Ten different distances, angles and areas were measured twice by one observer and once by another.

The time average of 10 repetitions of some functions of the computer program was compared to conventional measurement (Table 1).

Results

The error of the basic measurements was small (Table 2). The average inter- and intra-observer variation was 0.16 mm for distance, 0.18° for angle, and 0.13 cm^2 for area. Time was saved for procedures where multiple measurements, calculations, and comparison with normal values were included (Table 1), but not for single, simple measurements.

Table 1

Time in minutes (mean and range) for 10 evaluations performed manually and by computer

Measurement-calculation	Manual calculation mean (range)	Computer calculation mean (range)	Time saved, min
Angles in scoliosis	1.4 (1.1–1.8)	0.6 (0.4–0.8)	0.8
Kidney length and area (urography)	9.1 (7.0–12.2)	3.7 (3.1–5.1)	5.4
Kidney length (sonography)	2.5 (2.1–3.4)	0.9 (0.7–1.3)	1.6
Skeletal development	3.8 (2.8–5.1)	2.8 (1.8–3.8)	1.0
Heart volume	2.8 (2.3–3.3)	1.0 (0.7–1.3)	1.8

Table 2

Mean error and range of 20 repeated measurements of known distances, angles, and areas on millimeter graph paper

0 mm	0.06 (0.0–0.2) mm
100 mm	99.7 (99.6–100.0) mm
90°	89.94° (89.8–90.1°)
0°	0.02° (0.0–0.2°)
100 cm^2	99.8 (99.7–100.2) cm^2

Discussion

We have found a computer-based system for image measurements and analysis in pediatric radiology helpful. Assuming 10 calculations of heart volume, 2 of kidney length and area from urograms, 10 of kidney length from sonograms, 2 bone age determinations with prediction of final body length, and 5 multiple measurements of distances and/or angles daily in a department, the time saved is about 50 min a day. The computer equipment is inexpensive and can be programmed for various tasks.

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AN ULTRASONIC MULTIPURPOSE/ MULTIPLANE ENDOPROBE

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An ultrasonic endoprobe is specially designed for insertion in one of the natural openings of the body or for use during an open operation. The advantage of such a probe over the usual ultrasound transducer is that the endoprobe can be brought closer to the structure under examination and that the abdominal wall as well as possible gas-containing structures are bypassed. Thereby higher frequencies can be used, resulting in improved image quality.

The first endoprobe developed in 1950 by Wild was intended for measurements of the bowel thickness (6). Subsequently, various types of endoprobes intended for insertion into the rectum, the esophagus, the urinary bladder, and the vagina have been developed.

The images are produced with either a transverse or a longitudinal scanning techniqhe and the transducers are mechanical (a rotational or rocking transducer motion) or electronic (a linear or phased array principle). The usefulness of these probes has become increasingly apparent.

However, it soon became obvious that like conventional abdominal ultrasound scanning, endoscanning – especially rectal scanning of the prostate – requires imaging in orthogonal planes. If both a longitudinal and a transverse scan probe are available, biplane scanning can of course be achieved by insertion of one probe after another. However, this is not an ideal solution. It is difficult to obtain a precise perpendicular scan through a preselected area of the image by changing the probe. Changing the probe is also inconvenient and time-consuming.

A single probe which can provide two perpendicular or possibly multiple scans with a well defined axis of rotation through a target area is an obvious advantage. Such a probe should also possess the following qualities: a large field of view, real-time imaging, possibility for volume determination, for transrectal and transperineal biopsy as well as for ultrasound guided implantation of any array of needles for therapeutic purposes, e.g. radioactive seed implantation. Furthermore, the size and price should be acceptable.

Material and Methods

Existing bi- and multiplane endoprobes. Fourteen bi- and multiplane endoprobes from 12 manufacturers are available on the market (Fig. 1). They are of 7 different types, all of which have dynamic image presentation in both planes. Four (ATL, Toshiba, Aloka, and G. E.) (Fig. 1: A) utilize electronic beam steering in both planes. The remaining 10 are based on mechanical transducer motion. Eight of the probes have the advantage of a common image axis for the scan planes.

Since the basic idea of endoprobes is to get near the structure under investigation, a relatively high transducer frequency (5–7.5 MHz) resulting in optimal image quality is used in all the probes.

A multipurpose/multiplane endoprobe. During the construction of the new endoprobe, which has been developed primarily for prostatic use, the aim has been a multipurpose instrument applicable for multiplane imaging, volume determination, ultrasound guided biopsies, and transperineal implantation of radioactive sources in prostatic cancers.

The probe (Fig. 2) consists of a cylindrical handle with a 120-mm-long fingerlike protrusion (diameter 22 mm). Inside the tip of the probe a 7 MHz transducer (diameter 7 mm) is mounted which oscillates through a 112° angle (frame rate maximum 17 Hz) resulting in high resolution dynamic images. By means of a lever on the handle the scan plane can be changed from transverse through any desired oblique plane to longitudinal.

The common axis of rotation is perpendicular to the long axis of the probe (Fig. 3). To optimize prostate imaging and facilitate biopsies the rotation axis divides the 112° image into a 70° cephalad (or right) and a 42° caudad (or left) part. The common axis of rotation is indicated on the monitor by the line that can be drawn between the two white triangles situated at bottom middle and top right of the image frame. Any structure which by manipulation of the probe is transsected by this line is visualized in any desired plane by the turn of the lever. Furthermore, the chosen scanning plane is written in the textfield of the monitor at top right. A push button controls start-, freeze-, and photofunction.

The tip of the probe can be covered by a small rubber balloon which fits into a tiny grove close to the tip. The position of the balloon is secured by means of a small O-ring and the balloon can be filled with approximately 50 to 60 ml of degassed water through a fine internal canal, which ends in a tube connection at the handle. The tube connection is via a plastic tube and a stopcock, connected to a 60 ml syringe. The entire probe can be submerged for sterilization purposes.

Examination procedure. Gas in the rectum tends to disturb the image. This problem can usually be solved by placing the patient in the left lateral decubitus position. The waterfilled balloon also ensures contact with the rectal wall when the probe is placed at an optimal distance from the prostatic region under investigation, i.e. the region is in the focal zone of the transducer. The whole probe is covered with a gel-containing condom. It is important that all air bubbles are removed. After digital rectal exploration has been performed, the lubricated probe is introduced.

The ultrasound examination is usually started with transverse scans through the upper portion of the prostate and seminal vesicles and the scanner is then slowly displaced in a cephalad direction, thereby visualizing the total prostate transversally. Subsequently the scan direction is changed to longitudinal and the probe is slowly rotated, producing multiple fanlike longitudinal scans through the prostate and the seminal vesicles. Whenever a longitudinal as well as a transverse – or an oblique – scan of any specific structure is wanted, the probe is manipulated so that the structure is transsected by the oblique line between the two white triangles on the monitor,