RECENT ADVANCES IN ULTRASOUND DIAGNOSIS 3

Editors: A. Kurjak & A. Kratochwil

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Proceedings of the 4th European Congress on Ultrasonics in Medicine, Dubrovnik, May 17–24, 1981

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Foreword

Some 2,500 participants attended the 4th ECUM held in May 1981. The largest medical conference ever to be held in Dubrovnik, it achieved valuable results in scientific and personal exchanges. 526 papers were presented, either as invited reviews or free communications or at the various panels and workshops. Almost all of them are referred to briefly in the book of abstracts of the 4th ECUM issued by the Yugoslav organizing committee. They undoubtedly show a tremendous development in technology and application in almost every branch of clinical medicine.

As the editors of these Proceedings we take great pleasure in presenting this book which contains the results of 85 of the presentations. It was, however, very difficult to make the final selection of papers to be included, as most of those presented orally deserved to be published. We have done our best and believe that the papers not included will soon be appearing in the relevant medical journals. We hope that this volume will provide a valuable source of information on the impressive progress made in the field of diagnostic ultrasound.

A. Kurjak
A. Kratochwil

August 1981

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I. INTRODUCTORY

WHATEVER NEXT?

Ian Donald

Glasgow, Scotland

In looking into the future it is easy for one guess to get grafted on to another. I can only put forth tentative ideas, not on what has already been done but what I would like to do if I had all the apparatus I really wanted or could afford and all the time in which to use it.

There is plenty of room for expansion and advance, both for new clinical applications, calling if necessary for adaptation of existing apparatus and for even newer instrument technology.

Present limitations are provided in the case of "no-go" areas for example gas filled organs such as intestine and, to a lesser extent, lungs and, most serious of all, adult brain within its bony prison. Furthermore, use in operating theatres may be restricted in the case of existing instruments, by difficulties in achieving asepsis, totally reliable insulation from other gear in the presence of explosive gases, in manoeuvrability and in adaptability. We can expect to see most of these drawbacks overcome in time.

ACCESS

Compound scanning has always had certain advantages over sector scanning which is sometimes unfavourably influenced by shadowing although this may be useful in identifying sonically opaque objects such as gall stones. Compared with the single viewpoint of realtime scanning, it can "see behind" such ultrasonic opacities and the advantage of a stable gantry reference mechanism lies it its ability to provide a full length view from symphysis pubis to xiphisternum and transverse view from flank to flank. The human brain, however acts as its own computer in combining the limited views of realtime scanning into what compound scanning could have provided. This calls for a degree of expertise.

With real-time scanning has come portability. This in itself commends it to clinic and office use and may reverse the present trend to centralise ultrasonic equipment in static departments of radiology, as with C.A.T. scanning. This new trend will widen the scope of the subject and will involve a greater number of clinical departments which will introduce new ideas and applications. But it may also lead to poor quality work in careless or inexperienced hands.

The burning question of to-day is whether the new dynamic technology of R.T.S. can safely displace the older static systems.

The great advantage of speed and ease with which R.T.S. identifies the optimum scanning plane has to be offset against the manually operated B-scanners with their flexibility in providing linear, sector, arc and compounded displays.

Realtime scanners are of two main classes; the sector, with its keyhole view and the mouth organ type linear array with its view blinkered more or less to the length of the transducer array. Mechanical sector scanners are so much cheaper and perform so much better than present phased array sector scanners that they are likely to be popular for years to come. But linear arrays are easier for the novice to handle because of the proprioceptive recognition provided of the plane being examined. Nevertheless they afford poor access to tight corners such as the depths of the pelvis or the subcostal and intercostal planes or where surfaces are unyielding. At present their greatest use is in the middle trimester of pregnancy. The future, however, is likely to see some merging of linear and phased array systems offering flexibility comparable to mechanical B-scanners.

Moving structures cannot only be mapped and recorded but, even in cardiology R.T.S. may one day displace time-mode (T.M.) studies though not yet. The fetal heart and its components are obvious targets of interest, likewise respiratory and limb movements. The latest gating system for the former looks very promising for extended respiratory studies (Anderson et al 1980) but for abnormalities of limb movement we have found that slow motion recording is necessary for proper analysis.

In R.T.S. the amount of information in each frame depends on the number of information lines, or vectors which in turn depend upon the pulse repetition frequency which is best provided by a single slow pass sweep. This hybrid system, as my colleague Dr Roger Wild (6) calls it combines the advantages of rapid identification of the desired plane by R.T.S. and then slowing the spinning probe temporarily by a foot switch to furnish a very high resolution picture with a slow pass sweep as in mechanical sector scanning. We call this frame-grabbing whereas frame-freeze implies the instantaneous recall from computer store of a given picture at a given instant of time and is particularly valuable when the main object of interest is some rapidly moving structure such as a heart valve. A further press of the switch reverts the apparatus to its original real time function.

FILM ILLUSTRATION.

TISSUE CHARACTERISATION

Diffuse back scatter echos are omnidirectional and are consequently received weakly unlike specular reflections. They are diffuse because they originate from points that are small in relation to the wave length of the ultrasonic beam since they arise from tissue elements rather than organ surfaces. Furthermore the strength of an echo must depend upon the anatomical context of the tissues bounding either side of the reflecting interface. The transonic properties of those adjacent tissues are modified by the blood flow through them and this, in its turn, depends upon a number of factors such as inflammation, necrosis, whether pregnancy is involved or not and possibly other haemodynamic factors such as cardiac output and anaemia. All these variables are bound to make interpretation more difficult than in the case of optical histology where differential staining techniques can reveal all manner of hidden properties on light microscopy.

Sonar cannot rival histology as a definitive diagnostic subject except in respect of its non-invasive approach. Biopsy must remain the final arbiter. In screening for very early cancer changes at nuclear and subcellular level have to be reckoned with and, on occasion, even pathologists can disagree.

INTRALUMINAL DIAGNOSIS

The body has a number of orifices of varying degress of suitability for ultrasonic examination not yet as fully exploited as they might be. Comparable advances in fibreoptics give hope of similar advances in intraluminal ultrasonography. The rectum provides an obvious approach and has been used over the years. Rotating probes can investigate sectors of 90 degrees, 180 or even 360 degress depending on the number of transducers switched in on the rotating probe. A look round the exhibition will convince you of the potential of this method. I am familiar with the preliminary results of my colleague Dr Roger Wild in the case of the prostate examined per rectum. My own more amateurish attempts to depict malignant infiltration from carcinoma of the cervix provide no more than a challenge for the future. But with the right apparatus it is clearly feasible both for staging and estimating response to treatment.

There are also advantages in examining tissues in the near field as compared with the far field because of focussing difficulties with the latter and the need for larger diameter probes which nevertheless degrade resolution. The rectal approach might be regarded as "invasive ultrasonography" but it need not be classed as traumatic with proper instrument design. Higher frequencies producing better resolution will be generated by smaller transducers, and therefore more acceptable, without the penalties of attenuation while still in the near field. After all, no amount of technology will alter the basic physics of the subject. Depth of penetration varies as the wavelength; in other words inversely with the frequency. Maximal resolution therefore depends on maximal frequency which requires the closest approach to near field examination. Here lies the case for intraluminal examination inside hollow viscera when possible.

DYNAMIC FUNCTIONAL STUDIES

Realtime scanning makes this possible in all manner of studying behaviour and function but in none more impressively so than in the antics of the early fetus and its response to stimuli.

FILM ILLUSTRATION - acknowledgments to Action Research for the Crippled Child.

Videorecording of movements should preferable be made in slow motion in order to assess their true significance but we have not yet embarked on this.

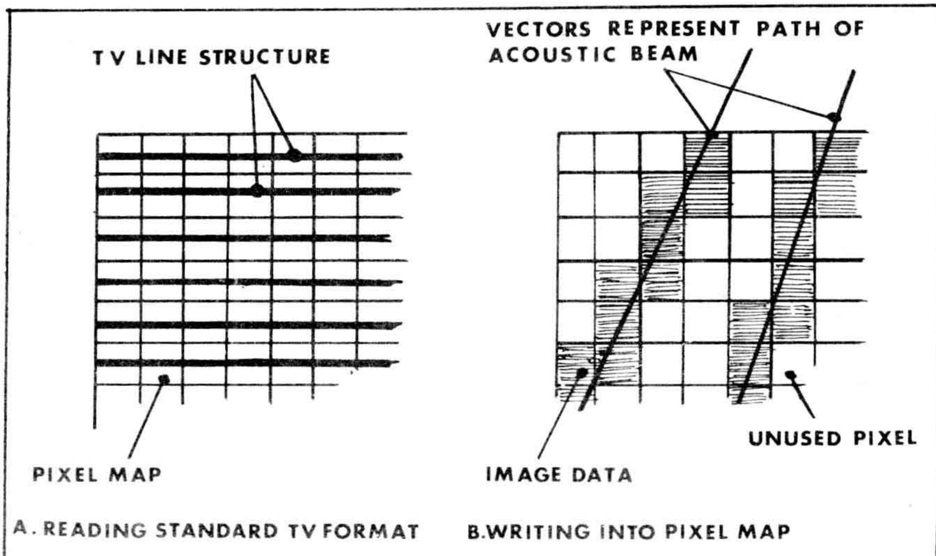

FIG.1 SCAN CONVERTER

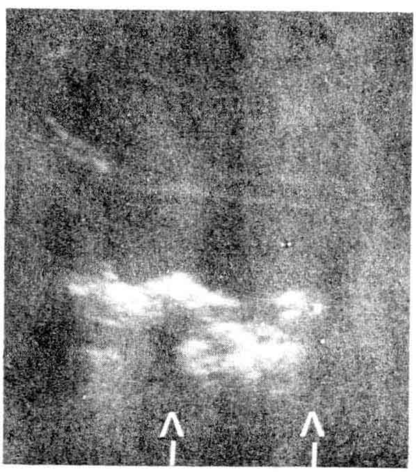

Fig 2.

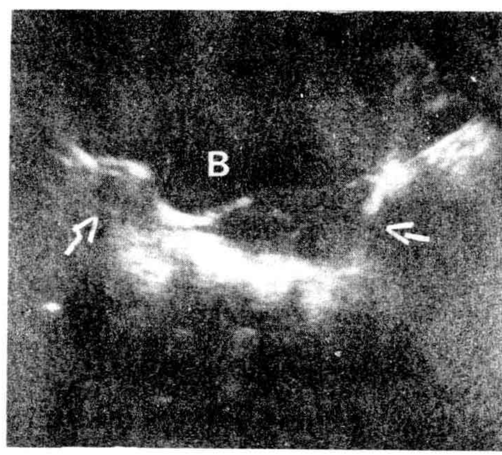

Fig 3.

Fig 2. Both arms of the Ovutektor prosthesis elevating the posterior bladder wall. Note ultrasonic shadowing

Fig 3. Oblique view of prosthesis to left, left ovary containing follicles and ovarian blood vessels on right of picture.

Figs 2 and 3 by courtesy of Dr Hackeloer.