RECENT ADVANCES IN ULTRASOUND DIAGNOSIS 2

Editor: Asim Kurjak

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1. INTRODUCTORY

A. Kurjak
I. Donald
G. Kossoff

WELCOME

This is the International Year of the Child. What occasion could be more fitting for such an event than this Third International Conference on the Recent Advances in Ultrasound Diagnosis--a meeting dedicated almost throughout to the welfare of humans from their earliest moments of embryonic life.

The participants in this meeting come from all over the world. Thirty-two countries are represented here, from as far apart as Australia and Japan to Europe and America. The Yugoslav Association of Societies for Ultrasound in Medicine and Biology and the city of Dubrovnik are proud indeed to be the host to so many men and women of international reputation. Among the many famous people here, I would like to distinguish two outstanding gentlemen, Professor Ian Donald, the father of diagnostic ultrasound in obstetrics and gynecology and Professor Inge Edler, the father of echocardiology.

At first, it may seem paradoxical that in a town as old as Dubrovnik, colleagues should gather to discuss ideas which project us all into the world of tomorrow, but perhaps Dubrovnik, by that enduring stability which comes with age, provides just the right environment for such an interchange. In a world where fortune now seems to change so rapidly, I believe we appreciate constancy more than ever before. But there is something else. Many of the delegates here also share a bond of friendship born of respect. Friendship has long been the thread which, in this old city, has woven together the past, the present and the future.

The word of friendship is "WELCOME". We have before us, for five days, not only the opportunity to work together but also, through our social program, to regenerate old friendships and create new ones.

Ladies and gentlemen, on behalf of the Organizing Committee, in the interest of science, and in the name of friendship, I bid you welcome.

A. Kurjak

MEDICAL SONAR - THE FIRST 25 YEARS

Ian Donald

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Consultant to EMI/Nuclear Enterprises Ltd,
Edinburgh, Scotland.

The first 25 years of medical sonar comes really as the finale in the much longer history of a subject whose origins go back into maritime history. What I have to say is no more than a personal account.

My often stated preference for the term "sonar" (which stands for "sound navigation and ranging") when referring to ultrasonic echography is based on my acknowledgement of this historical fact and our survival in the face of the German U-boat menace which, twice in my own lifetime, nearly defeated us in two world wars.

It was in about 1916/1917 that the French and British Admiralties formed a joint committee to counter the growing threat, the Anti-Submarine-Detection and Investigation Committee (ASDIC) and for whom the French physicist, Paul Langevin, (19) a one-time colleague of Marie Curie, conceived the principle of locating submarines in the ocean by using beams of sound waves of such high frequency as to be non-divergent and thus under directional control; and since the speed of sound, and therefore ultrasound in its passage through water is known, both the direction and distance of an object in the ocean could be determined.

As a schoolboy and student I knew of the application of the principle to depth sounding above the floor of the seabed from my enthusiastic attendance at engineering exhibitions at that time and, during my service with the RAF during the last war, I observed the fuller development of the technique of anti-U-boat warfare at closer and more sophisticated range. Little did I then think that I would one day apply it to the depiction of an early fetus in utero.

The miniaturisation of the technique came as a breakthrough in the USA during the last war by Firestone with his "reflectoscope" (14) for detecting flaws in metal structures, since the passage of a beam of ultrasound directly through a homogeneous metal was found to be interrupted in varying degree by cracks or flaws. This vital discovery was classified as a military secret and therefore not published until after the war but has since become

standard metallurgical practice in engineering and affords a much simpler alternative to cumbersome high voltage X-ray examination.

By the 1950s my interest was thoroughly aroused. As medical usage was unexplored my own opportunity roughly synchronised with my translation to Glasgow, a city with heavy engineering as its principal industrial activity.

It was shortly before leaving London that I met Jack Wild whose early work with Reid in Minneapolis I had already read about (24). Wild's misfortune at the time was the premature hope that he would be able to differentiate between malignant and non-malignant tissue, a matter which, to my surgically-trained mind, must still remain with proper histology. Wild told me that he was even considering the possibility of diagnosing a carcinoma of the stomach from within its lumen - I thought then, and still do, an improbable feat. Nevertheless, I persuaded the late Professor Ian Aird to grant him the opportunity of giving a University of London lecture which my departure for Glasgow prevented me from attending, nor could I find a published account of it.

On arrival in Glasgow in 1954 I soon set about trying to learn something about the energy properties of ultrasound and managed to borrow from an engineering firm a powerful ultrasonic generator situated in a bath of carbon tetrachloride in which it created massive turbulence. I then suspended samples of unclotted blood in it for varying periods and then, by cell counting, determined the degree of haemolysis. The heating effect in the case of control specimens was found to be entirely responsible for this destructive phenomenon and at this early stage I recognised that power ultrasound was destructive in proportion with its heat generating capacity - a fact born out later by many subsequent experiments of other workers and very fully confirmed by a team of Professor Wagai and his colleagues in Japan who visited me in Glasgow some years later and showed me the negative results of their exhaustive experiments using diagnostic types of ultrasonic energy. This provides another reason for preferring the term "sonar" to "ultrasound" which, in the eyes of the public, may conjure up visions of dental drills, cooking and instrument cleansing apparatus!

One of my initial clinical frustrations on coming to Glasgow was the problem of the woman with the grossly-distended abdomen in which the traditional methods of clinical diagnosis were simply inadequate. Those were the days of massive tumours, both ovarian and uterine, of ascites whether cardiac, neoplastic or hepatic in origin and of obesity such as one seldom sees in the working classes of today.

One patient was so obese that she had been bedridden for years, lying like a turtle on her back with arms and legs waving about like flippers. It took four nurses all their strength to turn her over in bed to attend to her pressure sores. I could not believe such abdominal distension could be due simply to obesity and not to a pelvic tumour, yet neither I nor my colleagues could make the diagnosis and I even recklessly considered getting my hand in by laparotomy to be sure. It was a humiliating bafflement, and by no means an isolated case.

Thus it came about that I began to copy the techniques of my new Glasgow engineering friends and sought help from their contact A-scan method of probing metal structures and welds for cracks and flaws.

I began by thoroughly digesting Carlin's textbook on ultrasonic physics (2). Then, by good fortune, the wife of an eminent engineer at this time gratefully survived a hysterectomy at my hands and introduced me to her husband. Following a lunch party with their research directors a session was arranged in the research department of Messrs Babcock & Wilcox. I shall always remember that hot sunny afternoon of 21 July 1955 when we took to the factory some selections of the last few days operating, in the boots of two cars, large ovarian cysts and uterine fibroids, calcified and plain. The firm very thoughtfully provided a truly massive piece of prime steak as a control material.

All I wanted to know, and this was surely not asking too much, was whether a metal flaw detector could show me on A-scan, which was then all we had, the difference between a cyst and a myoma and so forth. To my surprise and delight the differences were exactly as my reading had led me to expect, the cyst showing clear margins without intervening echoes because of its fluid content and the fibroid progressively attenuating the returning echoes.

Photographic facilities were not at that time available and the factory artist was called in to sketch the blips on the cathode ray tube face. Furthermore, it was noted that the degree of penetration was inversely proportional to the frequency. The steak gave confusing and intermediate results which was rather a waste, especially since nobody would accept it to take home for cooking!

Armed with this knowledge and with borrowed apparatus, I returned to the clinical problem of the grossly-distended female abdomen - initially a gynaecological problem (6). The study of pregnancy came later.

I suspect that most engineers are doctors at heart. They like mending machines but people as well

if they could. The converse is unusual although I may be an exception. My personal role throughout this quarter of a century's research has been insignificant and no more than that of a catalyst or synthesiser of the fertile minds of my engineering friends.

Babcock & Wilcox referred me to Messrs Kelvin Hughes nearby who manufactured the apparatus and whose attitude was equally generous, both with advice, the loan of apparatus and with expertise. Their directors came to lunch with me at the hospital and promptly voted the princely sum of £500 towards helping my research. In particular, Mr W T Slater, the Managing Director, provided invaluable help. They put me in touch with Professor Mayneord of the then Royal Cancer Hospital in London who was having a discouraging time with their mark 2 flaw detector on the cranial vault - we now know why.

As a result, this hellish machine was passed on to us. As far as I remember, it had a 1 or 1½ MHz quartz crystal and a paralysis time of 8 cms, i.e. nothing showed up within the first 8 cms of penetration.

This led us, inevitably, to devising water tanks with flexible latex bottoms which were applied with a film of grease to the protuberant female abdomen and into the surface of which our probes were cautiously dipped. Accidental spillages were frequent with such precarious balance and the resulting wet beds endeared me to neither patients nor nurses who had to clear up the mess!

Contraceptive condoms, blown up with water, seemed an obvious solution. Being rather well-known, by sight if not by repute, in a city like Glasgow I was naturally a little reticent in those days about being seen entering one of those shops for surgical rubber goods in West Nile Street - now long since swept away in a municipal slum clearance operation. My friend, the late Professor James Louw from Cape Town, was visiting me at the time and jumped out of the car offering to buy them for me. On being asked by the middle-aged blonde behind the counter whether he wanted teat-ended or plain he astonished her by saying that he would go out to the car and enquire! The puritanical nursing staff viewed the following experiments with even less enthusiasm, though less often inconvenienced.

Perhaps because of such failures, I developed a hearty dislike of tanks and stand-off mechanisms and from that time onwards have always favoured the direct contact approach as in engineering practice. I can remember arguing heatedly with George Kossoff, years later, in about 1960 when he visited me in my office, but I must admit that I had neither the

ingenuity nor the patience to go to the lengths which he has to secure ultrasonograms of his very striking quality.

Still limited to uni-dimensional A-scan, we got hold of a much improved mark 4 Kelvin Hughes flaw detector and tried to study the cranium with it, as had Professor Mayneord. Our distinguished colleague, Dr James Willocks, appeared to be the obvious subject for experiment having a head which was both large and bald. The fact that no intracranial echoes could be discerned gave rise to a lot of frivolous and uncharitable suggestions from all of us which were without scientific basis.

Returning to the problematical female abdomen, dramatic, life-saving success soon came our way. I was invited to see a poor woman who had a grossly-distended abdomen, believed due to massive ascites as a result of malignant portal obstruction. A barium meal X-ray had revealed a carcinoma of stomach and her case was regarded as hopeless with progressive anaemia from incessant haematemeses and rapid loss of weight. My own clinical examination of this very tense abdomen fully supported the physicians' diagnosis and I expected to find on A-scan examination a mass of bowel echoes in the central abdomen due to the presence of contained gas - as I explained to the surrounding throng of disbelieving medical onlookers. To my dismay all I could demonstrate was a clear space with, at great depth, a very strong echo so that I began to doubt the validity of the technique. My senior lecturer, John MacVicar, now Professor in Leicester, insisted that if this was not a large cyst then it ought to be. My own diffidence vanished when the physicians admitted with commendable modesty that they could, of course, be wrong. They agreed that, however hopeless, the patient deserved a laparotomy so she was transferred to my department. At operation I found a mammoth-sized mucinous cystadenoma which was entirely benign. Her recovery was immediate. Vomiting and haematemesis ceased, the X-rays were declared to be an artefact, she put on weight and remained well for many years when I lost sight of her with the family's emigration to New Zealand. This life-saving stroke of luck abolished all thought of slackening our research which had, up to then, been rather discouraging.

Soon I was being asked to do the impossible but fortunately a brilliant young man, Tom Brown, who was on the research staff of Kelvin Hughes, came on the scene. I was later to learn that the girl he subsequently married happened to be one of my staff nurses. He was also expecting to find himself on military draft as conscription still operated at that time. He soon made himself indispensable by