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MISCELLANEOUS

# The inaugurator of transmitted echocardiography: Prof. Dr Wolf-Dieter Keidel

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Usually, the inauguration of clinical echocardiography is attributed to Edler and Hertz who published their first paper in 1954,[1] followed by Japanese authors in 1956.[2] It is less well-known that there was a first description on using ultrasound for investigating the heart by Wolf-Dieter Keidel already a decade earlier[3] (*Figure 1*). His first investigations were conducted at the Physiologic Institute of the University of Erlangen, Germany, which had become prominent scientifically for its research and mathematical definition of human hearing and its work on audible sound. Apparently, the institute also became involved in the study of inaudible 'sound'.

In 1949 Keidel presented[3] and in 1950 he published[4] about the 'acoustic heart shadow' and its correlations to heart volumes and function. The title of the work was 'A Method to Register the Volume Changes in the Human Heart'. He tried to analyse the energy change of ultrasound transmitted through the thorax, analogous to radiographic examinations. Thus, his primary application of cardiac ultrasound was still based on transmitted sound waves, but he was nevertheless able to generate the first interpretable information about cardiac filling and physiology. Interestingly, this was accomplished by using very low ultrasound frequencies at 57.5 kHz.

*Figure 2* demonstrates Keidel's 'Ultraschallkardiogram',[3] an ultrasound cardiogram recorded at the third intercostal space and compared with the ultrasound cardiogram at the apex. The cardiogram was generated by a magnetorestrictive ultrasound transducer positioned on the back and a quartz receiver positioned on the front of the thorax. The signals were amplified and oscillographed by a three-graded ECG-amplifier. The ultrasound cardiogram demonstrates the amplitude of the ultrasound registered by the receiver that is dependent on loss of the transmitted signal due to absorption.

Keidel was a contemporary of Karl Theo Dussik, a neurologist and psychiatrist who graduated from the University of Vienna Medical School, at that time one of the largest and best in Europe. Dussik had anticipated research on diagnostic ultrasound within the field of neurology, particularly the examination of the human brain and ventricles, in 1941.[5] Much later, Douglas Gordon, a British ultrasound pioneer, in his book 'Ultrasound as a diagnostic and surgical tool' published in 1964, had expressly called Dussik the 'Father of Ultrasound Diagnosis'. Dussik's 'hyperphonography' was also—comparable with Keidel's method—a through-transmission technique with two transducers placed on either side of the head. These produced what he and his colleagues called 'ventriculograms', equivalent to ultrasound images of the ventricles of the brain. Pulses of 1/10 s duration were produced at a frequency more similar to that used in ultrasonic imaging nowadays (1.2 MHz) than that was used by Keidel (60 kHz). This was the first attempt at the concept of scanning a human organ.

At the First Congress of Ultrasound in Medicine held in Erlangen, Germany, in May 1948, two papers were presented which discussed ultrasound used as a diagnostic rather than a therapeutic tool. One was by Dussik presenting his hyperphonography of the brain and the other was by Keidel presenting the first echocardiogram.

Keidel discussed his research with researchers at Siemens. Together, they conducted all their experiments using the transmission technique, having rejected the pulse-reflection method. In those experiments, Keidel was able to make satisfactory recordings only of variations in intensity related to cardiac pulsations, and he envisaged that more difficulties would be encountered with the reflection method. His idea reinforced Dussik's notion that the transmission method was better, but 1952 W. Güttner and others at the Siemens Laboratories in Erlangen, Germany, had published data which demonstrated that Dussik's and Keidel's images were the result of imaging artifacts and that the through-transmission technique was suspect on account of the great absorption and reflection of ultrasonic waves. Similar scepticism resulted from research at the MIT (Massachusetts Institute of Technology, Cambridge, USA).

Owing to its ineffectiveness, the transmission technique in ultrasound diagnosis was almost completely abandoned from medical ultrasound research worldwide after the mid-1950s. It was replaced by the reflection technique which was deployed in nearly all of the pioneering centres in the USA, Europe, and Japan. There had been much debate at least on theoretical considerations, on whether the transmission or the reflection method should produce the intended results, from the late 1930s to the early 1950s,

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**Figure 1** Prof. Dr Wolf-Dieter Keidel.

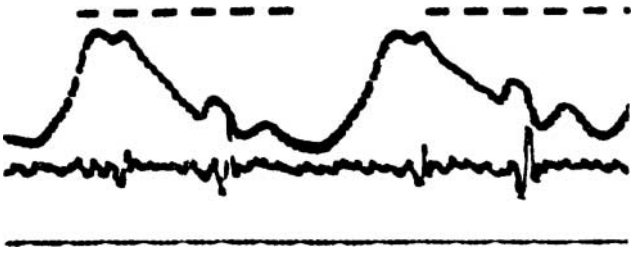

**Figure 2** Ultraschall Kardiogram from 1949 by Keidel.

until a definitive conclusion to use the reflection method was reached. Investigations using the reflection technique and pulse-echo ultrasound had taken off in the USA in the late 1940s. Nonetheless, Karl Dussik and Wolf-Dieter Keidel, despite their lack of success in making useful and valid images from their transmission techniques, must be credited for being the first medical persons to have applied ultrasound as a diagnostic tool in the examination of the brain (Dussik) and a little bit later of the heart (Keidel).

It was a pleasure for me to meet Prof. Keidel in March 2003, although the reason was less fortunate for himself since he was a patient at the stroke unit at University Clinic Erlangen, Germany. On this occasion Prof. Keidel told me about his former research on the 'acoustic heart shadow' and—as a physiologist who had not followed the development of echocardiography for decades—he was very impressed to hear about stress, tissue Doppler, and real-time three-dimensional echocardiography. As a physiologist focussing primarily on the physiologic senses, he had not continued on his initial, most important protagonist research on cardiac ultrasound.

Prof. Keidel took responsibility as a professor in ordinary of the chair of Physiology at University Clinic Erlangen, Germany, between 1961 and 1986. His main interest was biophysical techniques and later bio-cybernetics. His earliest publications focused on ultrasound in clinical diagnostics, optic, and acoustic prostheses in the 1940s and 1950s. Acoustic prostheses by cochlear implants followed in the 1970s and 1980s. One of his most important scientific accomplishments was objective audiometry (evoked response audiometry, ERA). Owing to his experience of the first generation of computers, produced at MIT, he was the first in Europe to apply computers in physiologic laboratories. All these activities were pioneer works but not seldomly their significance was proven only later, for instance, in aircraft and space medicine or in medical spectrophotometry. As Keidel was a physiologist and not a clinical cardiologist, his ultrasound work seems to have awaited its recognition until nowadays. Also, in general, the time when he inaugurated cardiac ultrasound had not been well suited for recognizing the potential importance of the echocardiographic technique, as it was the time when heart catheterization attracted much more attention. Almost two decades later, and after the early work on reflected ultrasound by Edler and Hertz in Lund, the method was developed and spread rapidly in the USA[6] from where an appreciation of its clinical significance returned to Europe only in the 1960s and 1970s.

Keidel was honoured by several awards: The 'Silver Certificate as Fellow of the Acoustical Society of America', the 'Honour Label of the Tokyo Medical and Dental University', 'Fellow of the MIT', 'Member of the Academia Leopoldina', 'Professor honoris causa of the Universidad de Concepcion/Chile', and many more. He celebrated his 90th birthday on the 14 December 2007.

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