

**Field: Technological integration of  
medical science and engineering**

**Achievement: Contribution to tomographic imaging  
in nuclear medicine**

**Dr. David E. Kuhl**

Born: October 27, 1929 (Age 79)

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**Summary**

Today various types of diagnostic imaging systems including CT (computed tomography) are used on a daily basis in hospitals and clinics all over the world. Dr. David Kuhl, one of the world pioneers in tomography, began experimenting in the late 1950s by taking cross-sectional images of the distribution of radioisotopes in the body. He went on to develop SPECT (single photon emission computed tomography) in the late 1960s and succeeded in producing the world's first tomographic images of the human body. In addition to having a profound impact on the subsequent development of X-ray CT scanning and MRI (magnetic resonance imaging), Dr. Kuhl's research brought about the realization of PET (positron emission tomography), which is proving to be invaluable in the early detection of cancers.

**Success in the world's first tomographic imaging**

It was Roentgen's discovery of the X-ray that first fulfilled the dreams of medical practitioners who wanted to study in detail the inside of the human body without hurting the patient with the use of a surgical knife. Today X-ray imaging is still widely used in the diagnosis of bone and lung diseases but it was the development of computed tomography (CT) from the late 1960s to 1970s that brought about groundbreaking advances in diagnostic imaging technology. It was this technology that made cross-sectional images of the body possible and enabled more detailed investigation of internal organs.

Today in the field of medicine various medical diagnostic devices are widely used in clinical applications such as X-ray CT scanning, magnetic resonance imaging (MRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT). However, it was the development of SPECT by Dr. Kuhl that was at the forefront of groundbreaking imaging technologies. Unlike X-ray CT scanning, which produces tomographic images from the absorbed amount of X-rays the body is exposed to externally, SPECT is a diagnostic system that produces images by picking up gamma radiation emitted by a minute amount of a radioactive agent injected into the body. By capturing the dynamic state of the agent inside the body, SPECT reveals physical functions such as vascular flow and the metabolism of the internal organs.

In terms of achieving tomographic imaging of the human body, SPECT developed by Dr. Kuhl predated X-ray CT scanning and his research had a significant impact on the development of various diagnostic imaging devices. Because of his achievements in this area, Dr. Kuhl is known as the "Father of Emission Tomography."

**Accelerating the development of diagnostic imaging including CT**

Born in 1929 in St. Louis in the eastern part of Missouri in the United States, Dr. Kuhl was interested in chemical experiments from

the time he was a child and during high school earned recognition for his experiments using radioisotopes. He went on to study at Temple University's Department of Physics but ended up choosing the application of radioactive substances in medicine as his final research topic.

Dr. Kuhl received his Doctor of Medicine degree from the University of Pennsylvania in 1955, at the very time when nuclear medicine was in its infancy. Three years later, in 1958, the scintillation camera was developed. This camera produced images of the distribution of a radioactive agent injected into the body. However, Dr. Kuhl was not satisfied with this technology. As a camera designed to observe two-dimensional projections of a radioactive agent distributed inside the body three-dimensionally, it was not able to provide quantitative data as to how much agent existed inside the body and where.

To resolve this problem, a research group at the University of Pennsylvania embarked on a world first study of tomographic imaging of the distribution of radioisotopes within the body. Later proposed by Dr. Kuhl in 1962, the imaging technique the group developed was based on the principle of emission CT, which is to produce tomographic images of the body through computer analyses of radiation data obtained from all directions of the body over a 360-degree range (see diagram). Essentially, the computer at this time performs an enormous series of matrix operations where one cross-section is divided into a reticular pattern where the amount of radiation in each segment is set as an unknown quantity. A simultaneous equation where the total is made to equal the actual amount of radiation is then used.

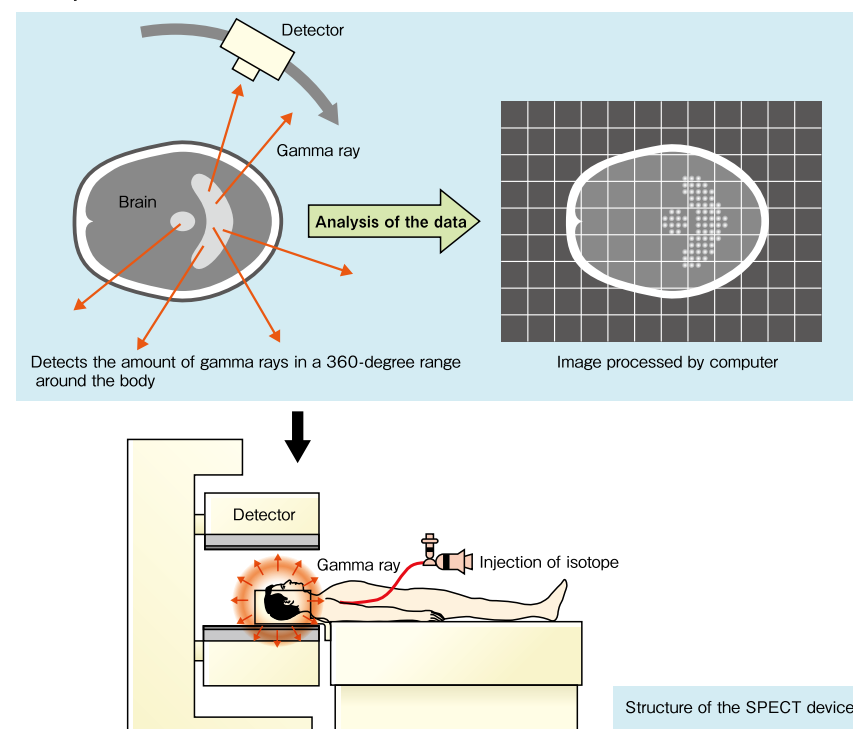
In 1964 the research group developed the Mark II SPECT series, which is a single photon emission computed tomography camera. With this unit, the group succeeded in producing the world's first tomographic images of the human body. This achievement was considerably earlier than Godfrey Hounsfield's development of the X-ray CT device in 1972.

**Development as a device for observing physical functions**

With his development of the Mark III in 1970 and the Mark IV scanners in 1976, Dr. Kuhl opened up new possibilities in nuclear medicine. X-ray CT later developed as a means of accurately viewing the physical shape of organs while SPECT developed as a technology for viewing the various functions of the body such as vascular flow, metabolism, and neural transmission, among others. Even today SPECT is widely used in hospitals and clinics.

At this time Dr. Kuhl and his team of researchers were also focusing their efforts on the practical application of PET. If the metabolism of glucose, the energy source supporting the body's vital activities, could be captured, the imaging of various biological functions would be possible. However, to make glucose emit nuclear radiation, it would be necessary to label it using positrons rather than radioisotopes, which were generally used at the time. That is why this technique is referred to as "positron-emission tomography" or PET, separate from SPECT.

**Principles of SPECT**



Dr. Kuhl's interest in the use of positron emitters began when Dr. Sokoloff, who was researching animal brains at the National Institute of Mental Health in the United States, used C-14, a positron-emitting radionuclide, to successfully label 2-deoxyglucose, a type of glucose, and measure its concentration distribution through autoradiography. Following on from this success, Dr. Kuhl's group began joint research with Dr. Sokoloff, and Dr. Wolf from Brookhaven National Laboratory and later came to the conclusion that FDG (18F-2-Deoxy-2-fluoro-D-glucose), which labeled F-18, was the most suitable positron emitter that can be used with humans. In August 1976, FDG synthesized at Brookhaven National Laboratory, was sent to the University of Pennsylvania where Dr. Kuhl's group succeeded in realizing the first metabolic imaging of the human brain using a SPECT Mark IV scanner.

The recent development of PET devices using FDG has been proceeding at a rapid pace. This is because PET devices are proving to be highly effective in the early detection of cancer. Glucose metabolism in cancerous tissue is higher than in normal tissue. At the same time, image fusion technology is advancing, and PET-CT, a combination of PET and X-ray CT, is playing an important role in the diagnosis and treatment of diseases such as cancer and cranial nerve disorders.

In these ways diagnostic imaging technologies are making a significant contribution to progress in medical treatment. At the leading-edge of research, the development of various molecular probes is currently underway and molecular imaging, which will reveal the behavior of molecules in living bodies, is becoming a reality. Imaging technologies are not only making a significant contribution to progress in medicine today but are also expected to unravel the mysteries of life as they develop.