Chapter 1
Historical Background

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Prologue

It was a dark evening in the late autumn of 1978. A middle-aged woman was urgently admitted to our hospital in Kyoto because of anuria for a few days. She had suffered from cancer of the right ureter and undergone nephro-ureterectomy. The anuria resulted from an obstruction of the contralateral ureter due to a recurrence of bladder tumor. An immediate catheterization from the left renal pelvis by nephrostomy was indicated.

Even now, senior urologists may remember very well what a dreadful surgery classic open nephrostomy was. The kidney was exposed after a large incision in the back, then a thick trocar was introduced blindly from the renal surface into the pelvis, because there was no means of guidance. Heavy bleeding often occurred. Since this was only a palliative treatment, there was a big imbalance between the risks of the invasion and the possible gains.

A week previously, we had taken delivery of a new machine direct from the manufacturer. It was the world's first mechanical sector scanner with a special attachment, which we had designed originally for real-time puncture guidance. After intense discussion among the staff of the risks involved, we made up our minds to introduce the machine in this case. None of us had yet used it, and only a few foreign reports on the procedure were available at the time, which was named later as percutaneous direct nephrostomy.

The patient was moved to the operating theater for general anesthesia. The scanner was positioned on her back, and a clear image of the hydronephrotic renal pelvis appeared on the oscilloscope. All the staff member of our department gathered and watched the operation, praying to God for success. At the first shot, puncture to the pelvis was achieved very easily and a catheter was placed correctly in a few minutes. Everybody was amazed and felt that this was a real innovation.

Only several months later, I found incidentally a young resident carrying out the same interventional operation at the bedside under local anesthesia. He was never nervous but was smiling, joking with the patient. Of course all the procedure was completed in safety. I understood that the technique had already been subsumed into everyday routine work.

The Period of the Central Canal Type Transducer

It is very difficult to determine who made the first application of interventional ultrasound, because ultrasound pictures were commonly used as reference images for puncture, even before the proposal of intervention techniques. Among the pioneers, Berlyne[1] in England is generally credited as the person who made the first trial intervention. He performed renal biopsy under the guidance of an A-mode chart recorded by an industrial flaw detector in 1961, only a few years after the first introduction of ultrasound in medicine.

In my opinion, however, the history of interventional ultrasound should start from the first development of a special apparatus designed purely for the puncture guidance.

A Danish urologist, Hans Herik Holm[2] (Fig. 1.1), and an American radiologist, Barry B. Goldberg[3] (Fig. 1.2), independently published the same idea of a "central canal" type transducer in the same month in different journals in 1972 (Figs. 1.3 and 1.4). Both transducers were designed to be attached to a "contact compound" B-mode scanner, which was the standard procedure for sonography at that time, to target the site by a needle inserted through the central canal of it.

Holm's group pioneered puncture to various organs with their transducer: the liver, pancreas, kidney, uterus, and so on. They used the term "ultrasonically guided puncture" for the procedure. On the other hand, Goldberg focused the object mainly on the aspiration of various fluids from within the body. "Ultrasound-aided needling" was his favorite term. However, a new term, "interventional ultrasound," which was derived from basic radiology terminology, has gradually become general at the international level since the 1980s, because this describes the technique compactly and sounds harmonious.

Though it is accepted that these two groups opened up the possibilities of ultrasound intervention, their idea of the transducer

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FIG. 1.1. A portrait of Hans Henrik Holm at the First International Workshop on Diagnostic Ultrasound in Urology and Nephrology, Kyoto, 1979. Hans Henrik has retired but is still active in good health

FIG. 1.2. A portrait of Barry B. Goldberg at the same occasion. Barry is hard at work as an academic researcher

having a central canal was not original. Earlier in 1969, an Austrian gynecologist, Alfred Kratochwil.[4] (Fig. 1.5), had already presented before a congress his trial on puncture to the amniotic cavity with a similar type of transducer developed by him, which was attached to an A-mode (only the intensity of the echo signals is shown on an *X*–*Y* graph) machine.

Anyhow, at this stage of the development, the procedure had not yet become very popular, because the imaging technique was inadequate for intervention. In the former "contact compound" scanning, a 2D image was constructed manually with the transducer being slid around the body surface. It took a considerable number of seconds to complete a cross-section picture. Although the target could be indicated on the picture, it vanished when the needle was inserted. No monitoring of the needle pathway was possible. Of course, A-mode gave far less information than B-mode.

The Period of Real-Time Intervention

The emergence of real-time scanners in the late 1970s eliminated the weak point mentioned. Only after this innovation did interventional ultrasound become accepted as an established technique for puncture guidance.

The first transducer for real-time intervention, though a kind of working model of electronic scan, was reported by a Danish group in 1977[5] (Fig. 1.6). Saitoh and Watanabe in Kyoto developed a commercially available puncture attachment for a newly developed compact mechanical real-time scanner (Fig. 1.7) in 1978[6] and started to seek out various indications of the puncture system in urology. The story described in the prologue happened in those days. Goldberg et al. also reported their new machine in 1980.[7] Since then many reports have followed from all over the world.

After the introduction of real-time intervention, various kinds of novel diagnostic and therapeutic means, which were never possible in the early days, have been realized. Among these innovations, the most important contributions to medicine, from the viewpoint of frequency of performance, must be selective renal biopsy and percutaneous lithotomy.

In nephrology, renal biopsy is an essential step in the differentiation of diseases. Open biopsy or blind percutaneous biopsy, which was generally performed in the early days, was invasive and risky. Unexpected bleeding occasionally caused a

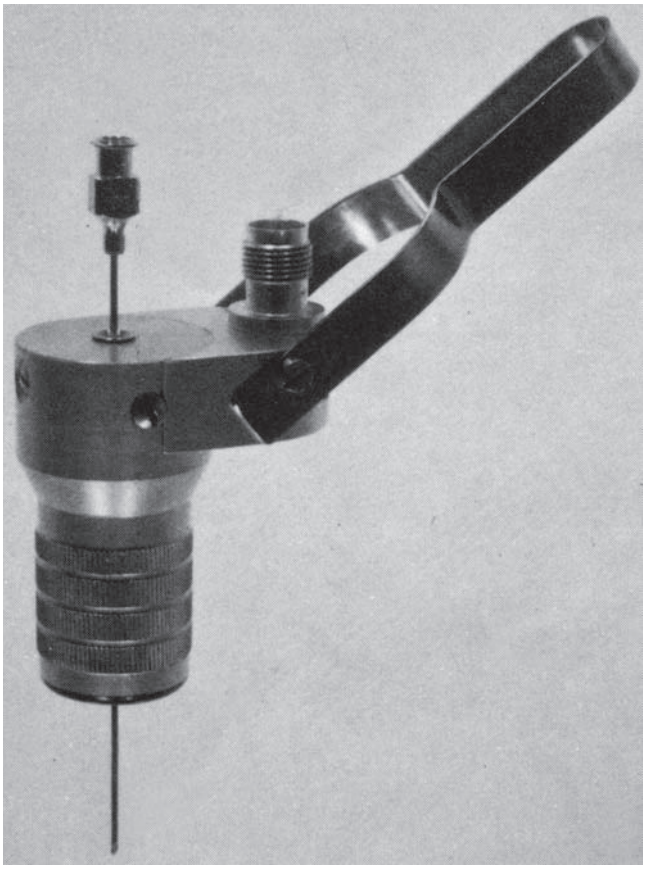

FIG. 1.3. The "central canal" type transducer developed by Holm et al.[2] Reproduced from Kristensen JK et al., Ultrasonically guided percutaneous puncture of renal masses, Scand J Urol Nephrol 1972; 6(Suppl): 15, 49–56

FIG. 1.5. A portrait of Alfred Kratochwil, on the same occasion as Figs. 1 and 2. Alfred occasionally gives fine lectures at meetings with his skilful computer presentation

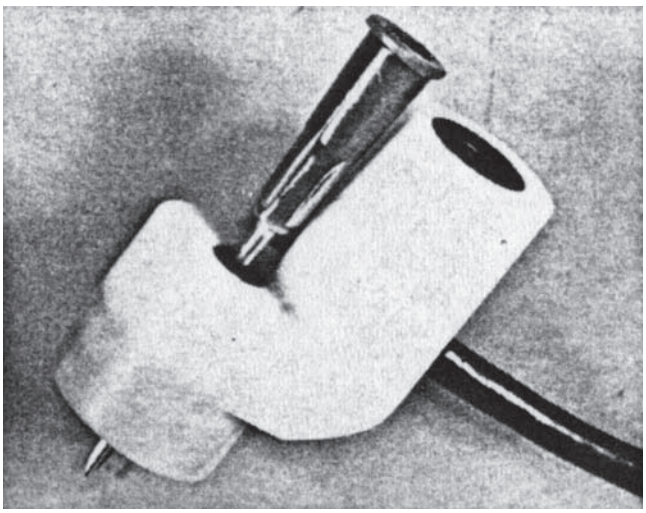

FIG. 1.4. A similar transducer developed by Goldberg et al.[3] Reproduced from Goldberg BB, Pollack HM[3]

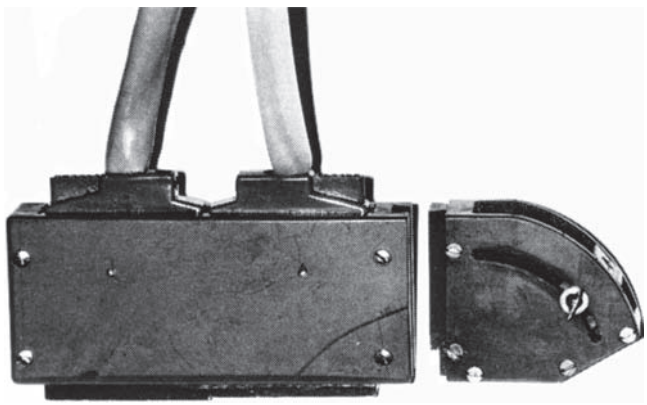

FIG. 1.6. An electronic real-time scanner with a puncture attachment by Pedersen.[5] Reproduced from Holm HH, Kristensen JK[24]

fatality. Selective renal biopsy under ultrasonic real-time guidance[8] brought a dramatic improvement of the technique, both in terms of on safety and accuracy. Today's professionals easily take a biopsy sample selectively from a target less than 1 cm in diameter in any portion in the kidney under local anesthetic.

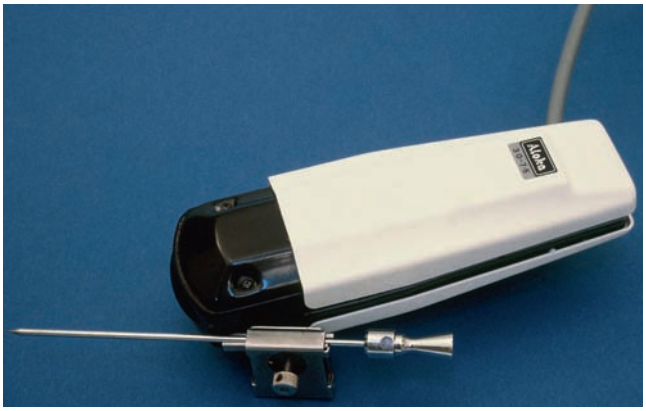

FIG. 1.7. A mechanical sector scanner with a puncture attachment by Saitoh et al.[6]

FIG. 1.8. A portrait of Masahito Saitoh, during his first successful surgery for single-stage percutaneous nephroureterolithotomy in 1981[9]

Percutaneous lithotomy was also revolutionary for the treatment of urinary calculi. This generated the vogue word, "Perc," among urologists in the late 1980s. Saitoh[9] (Fig. 1.8) first succeeded in percutaneous nephroureterolithotomy using a special ultrasonically guided pyeloscope in a single stage (several previous reports were available on lithotomy through an already-established nephrostomy channel by surgery) in 1981.

Intervention by Transrectal Ultrasound

Transrectal ultrasound[10,11] is a special technique developed for urology in 1967. In the early period of the method, horizontal sections were obtained by rotation of a single transducer inside the transrectal probe with an electric motor set outside the probe, while sagittal sections were made by manual pulling-down of the transducer. Even in this period, prostate puncture guidance was feasible, but the introduction of a real-time transrectal transducer encouraged the rapid distribution of the method at the worldwide level.

In this case again, the Danish group and the Japanese group were competing with each other. Holm and Gammelgaard[12] published a needle guidance system for puncture to the prostate and the seminal vesicles, monitored by ordinary transrectal ultrasound in 1981. On the other hand, Saitoh and Watanabe[13] had reported a puncture system using a newly developed transrectal electronic linear scanner with a needle guidance attachment in 1980 (Fig. 1.9). In this system, a longitudinal section of the prostate was delineated to monitor the advance of the needle directly in real time. Some authors[14–16] followed this system, employing Japanese probes, then ultrasound intervention came to be recognized as an indispensable procedure for prostatic biopsy. In recent days, the system has been modified to enable switching between two sections, horizontal and longitudinal, by using two different transducers fixed rectangular at the tip of the transrectal probe.

As is well known, the diagnosis of prostatic cancer is made by prostatic biopsy guided by interventional transrectal ultrasound

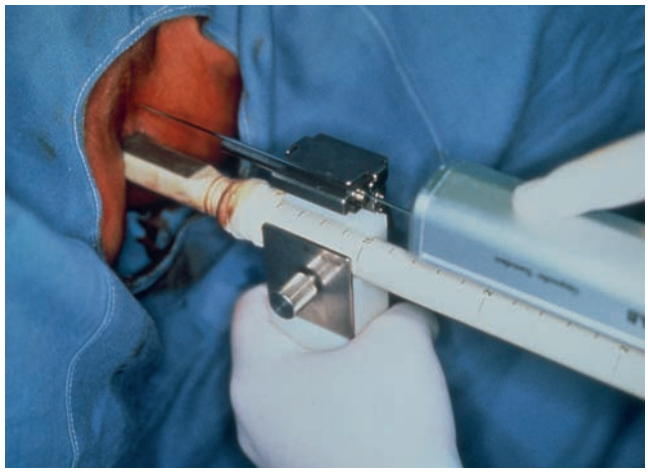

FIG. 1.9. Transrectal real-time linear scanner with a puncture attachment by Saitoh et al.[13]

alone today. Lee[17] and Cooner[18] promoted this routine in the late 1980s in the United States. Stamey and Hodge[19] established the concept of multicore biopsy, which is accepted as the gold standard worldwide.

Brachytherapy (radioisotopes' implantation) for prostatic cancer has become very common. Nowadays more than 60,000 patients a year undergo the procedure in the United States. Although originally conducted by retropubic open surgery,[20] the introduction of transperineal seeds insertion under interventional transrectal ultrasound by Holm[21] in 1981 greatly improved the technique. Presently available equipment for this therapy mostly benefits from his improvement.

References for Interventional Ultrasound

In the final part of this chapter, the titles of special books for interventional ultrasound published during the period described (Fig. 1.10) will be listed.

The first book for this purpose was *Ultrasonically Guided Puncture* written in Japanese language in 1979.[22] This was planned to publish the results of a special symposium with the same title, organized by the Japan Society of Ultrasonics in Medicine in December, 1978, in Kyoto. With the expanding demand in the field, another book written in English, *Interventional Real-Time Ultrasound* was published in 1985.[23]

The Danish group released two books for the same purpose in 1980[24] and in 1985.[25] They were based upon the two meetings of the International Conference on Ultrasonically Guided Puncture, held in Copenhagen in 1978 and 1983, sponsored by the Danish Society of Diagnostic Ultrasound. The first book dealt mainly with the central canal type transducer, while the second focused on real-time intervention.

Another essential book[26] and important articles on the history of interventional ultrasound[27–31] are also listed here.

Fig. 1.10. Special books on interventional ultrasound

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