Foreword

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The development of ultrasound as a new imaging modality occured during the second part of the last century, and at the same time percutaneous puncture techniques also became increasingly important. Previously fluid collections, e.g. pleural effusions or ascites and even amniotic fluid (amniocentesis), were localized and punctured based on anatomical landmarks and percussion. Percutaneous liver biopsy developed by Menghini in 1958 [1] had become established as a standard method. However, percutaneous biopsy of the kidneys continued to be a problem because radiological pyelography, the only existing imaging modality to show the kidneys, was dependent on renal function and did not demonstrate the third plane, the distance between the skin and the lower pole of the kidneys. Therefore, Berlyne [2] used the new ultrasonography technique as early as 1961 to measure the distance between the surface of the skin and the lower pole for safer puncture of the kidneys. Furthermore, the new two-dimensional imaging technique was used for puncturing fluid collections that were difficult to localize by percussion or anatomical landmarks alone. A further advantage of this new imaging modality was the reliable differentiation between fluid and solid tissue using A-mode, additionally in the early years and then later using real-time/grayscale technique directly. As a result, ultrasound enabled less risky puncturing of amniotic fluid as reported by Kratochwil in 1969 [3] and lowered the risks of pericardiocentesis as introduced by Goldberg in 1973 [4].

In 1930 Martin reported the first attempts to puncture palpable, i.e., superficial, masses percutaneously in order to clarify their nature based on cytological analysis [5]. However, broader application as a routine method to diagnose tumors was accepted in Scandinavian countries only. The suspicion of a malignant tumor in an organ like the liver was considered a contraindication for percutaneous puncture primarily because of the risk of a bleeding.

With the further improvement of ultrasound, soon even smaller lesions in parenchymatous organs in the abdomen could be detected. Cystic lesions could be precisely differentiated from solid tumors. However, a differentiation between benign and malignant tumors did not become possible, in spite of attempts to use ultrasound for "tissue characterization". Nonetheless, each detected lesion could be precisely localized in all 3 planes. The idea of puncturing these lesions with thin, "fine" needles and analyzing the aspirated material to clarify the nature of the lesions was therefore obvious. Blauenstein und Engelhart [6] demonstrated this new technique for the first time in Vienna at the first worldwide congress for ultrasound.

Therefore, ultrasonically guided transcutaneous puncture techniques have two origins: the improvement of routinely used percutaneous puncture techniques for the diagnosis and therapy of fluid collections and the puncturing of sonographically detected lesions to clarify their nature. This new technique was used and further developed by several authors at several institutes working with ultrasound at the same time. However, Copenhagen became the center, at the institute of HH Holm. There he organized the first international congress in 1978 to discuss this new technique. He and his coworkers edited the first book on INVUS in English in 1980 [7]. Japanese authors had also been very active. They published the first book in Japanese in 1979 [9].

The first punctures were carried out with typical normal needles after localization of the target in 2 planes and measuring of the distance between the skin and the target, as described by Blauenstein in 1969 [6]. The needle could be visualized with the transducer held in the examiner's other hand and placed skin surface – the so-called "freehand puncture technique". However, the broader use and acceptance of this new technique prompted users and the medical industry to develop special biopsy transducers. The first prototype of a single probe transducer with a central hole, used in connection with a compound scanner, was demonstrated by Kratochwil at the Vienna conference 1969 [3]. Shortly thereafter, manufacturers began commercially offering biopsy transducers for compound machines. With these biopsy transducers, an A-mode signal could be seen on a previously acquired and stored B-mode image.

The construction of biopsy transducers for newer real-time scanners was more difficult from a technical standpoint. In cooperation with the Aloka company, Japanese authors Saitoh and Watanabe introduced a mechanical scanner with a puncture attachment in 1979 [10]. In 1977 the Danish group developed a puncture attachment for a linear probe in-house [11]. The needle could be introduced through these attachments from the side at different angles into the tissue and the acoustic field so that permanent "real-time" control was possible. The manufacturer Toshiba then offered linear array probes with a triangular needle channel in the center, into which disposable needle guides could be inserted. Here, the needle path corresponds to the path of the ultrasound

Bibliography
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beam but could also be angled. The digitalization of ultrasound machines made it possible to plan the needle path with a virtual (electronic) line on the screen.

The disposable inserts made handling easier, even from a hygienic standpoint. However, longer needles were needed when using needle guidance. At the same time special needles, which enabled biopsies even in the case of a diameter of less than 1 mm, were developed [12], but studies at this time did not show superiority of one microscopic method over another. Special instruments, which enabled a fully automatic or semi-automatic puncture procedure, were additionally developed. Thus, puncture could be performed by one person.

Several authors nevertheless continued to use freehand puncture as it was flexible, did not require special biopsy transducers and needles and was less expensive in a hygienic as well as technical and financial respect. Perhaps this was the reason that special needles which showed an improved signal on the ultrasound image, e. g. by a special surface, were not really accepted [13].

In summary, it could be stated that by around 1990 all sonographically demonstrated "targets", whether tumor, cystic lesion, fluid collection or duct system could be reached with an ultrasonically guided needle [7, 12].

Larger studies done at that time in Germany [14, 15] and Italy [16 – 18] showed that the risk of bleeding, as feared in the beginning, was very small if there were no risk factors and the needle diameter was less than 1 mm.

In the beginning based on case reports and later in larger studies, the risk of needle tract seeding became evident as a special problem [14 – 18]. This rare but severe complication seems to be dependent on the type and biology of the tumor, on the affected organ, as well as on the needle size and type [15].

The growing tendency at this time (around 1990 – 95) to puncture each lesion detected by ultrasound immediately as an integral part of the examination (as in the case of gastrointestinal biopsy) was not accepted by all authors and physicians, perhaps as a result of this problem of needle tract seeding. The opposing view was that the ultrasonically guided interventional procedure changes ultrasound from an absolutely risk-free method to an intervention that carries risk and therefore needs its own clear indication.

Although it was a short leap from diagnostic puncture to therapeutic procedure in the case of the puncture of pathologic fluid collections, this step was not undisputed. In the beginning the drainage of abscesses and congested duct systems was criticized because of the concern that catheters placed via these puncture needles would be "much too thin". The puncturing of true cysts with emptying of all fluid in a single session was obviously not successful because of the secreting epithelial layer, which produced the fluid repeatedly. Therefore, it was necessary to destroy this layer by the instillation of sclerosing agents. For the therapy of pancreatic pseudocysts, Hancke [19] of the Danish group introduced in 1985 a combined sonographic and endoscopic technique [19]. In 1995, P. A. I. R. was developed as a special puncture technique for the treatment of hydatid cysts, as an alternative to surgical options [20].

It is interesting that the pioneers of therapeutic interventions have mainly been Italian authors. They transferred the idea of destroying the secreting epithelium of cysts to the destruction of the secreting tissue of benign endocrine adenomas as well as to the destruction of malignant tumors. Solbiati [21] introduced in 1985 the destruction of parathyroid adenomas and Livraghi [22] reported in 1990 the treatment of autonomous nodules of the thyroid by the instillation of ethanol. He introduced the same technique (PEI) for the treatment of hepatocellular carcinomas. Alternatively, the ablation of liver tumors and metastases with radiofrequency was developed [24].

The possibility to puncture detected lesions was consequently integrated from the beginning of the development of ultrasonic endoscopes around 1980. It started with endosonography of the prostate. The Japanese group of Saitoh/Watanabe [25] and the Danish group led by Holm [26] presented their combined systems nearly at the same time in 1980 and 1981, respectively.

Alltogether parallel to the introduction and improvement of ultrasound diagnosis, a broad spectrum of "minimally invasive" ultrasonically guided diagnostic and therapeutic procedures (INVUS) was developed and can be seen, given a correct indication and careful execution, as relatively gentle for patients and relatively less expensive in comparison e. g. with surgical procedures. Guidelines created by many experienced authors in Europe are useful and necessary to improve and maintain the quality of these "minimally invasive" procedures. However, it should not be forgotten that the development of these interventional ultrasonic methods was only possible because the pioneers many years ago did not hesitate to risk steps beyond the standards of their time.

Literature

1 *Menghini G.* One-second needle biopsy of the liver. Gastroenterol 1958; 35: 190 – 192
2 *Berlyne GM.* Ultrasonics in Renal Biopsy. An Aid to determination of kidney position. Lancet 1961; II: 750 – 751 (preliminary communication)
3 *Kratochwil A, Lim-Rachmat F.* Ultraschallplazentalokalisation. In: Böck J, Ossoinig K ed Ultrasonographia Medica. III: 275 – 284
4 *Goldberg BB, Pollack HM.* Ultrasonically guided Pericardiocentesis. Amer. J. Cardiol 1973; 31: 490 – 493
5 *Martin HE, Ellis B.* Biopsy by needle puncture and aspiration. Ann. Surgery 1930; 92: 169 – 181
6 *Blauenstein W, Engelhart GJ, Müller HR.* Sonographie und stereotaktische Biopsie von Lebertumoren. In: Böck J, Ossoinig K eds Ultrasonographia Medica. III: 93 – 99 Holm HH
7 *Holm HH, Kristensen JK.* Ed. Ultrasonic guided puncture technique. Copenhagen: Munksgaard; 1980
8 *Watanabe H, Wagai T, Takehara Y.* (ed.) Ultrasonically guided puncture. (In Japanese)
9 *Goldberg BB, Pollack HM.* Ultrasonic Aspiration Transducer. Radiology 1972; 102: 187 – 189
10 *Saitoh M, Watanabe H, Ohe H et al.* Ultrasonic real-time guidance for percutaneous puncture. J Clin Ultrasound 1979; 7: 269 – 272
11 *Pedersen JF.* Percutaneous puncture guided by ultrasonic multitransducer scanning. J Clin Ultrasound 1977; 5: 175 – 117
12 *Otto R, Wellauer J.* Ultraschallgeführte Biopsie. Berlin: Springer; 1985
13 *Heckemann R, Seidel KJ.* In vitro- und in vivo- Darstellungen von Punktionsinstrumenten im sonographischen Echtzeitbild. Ultraschall 1982; 3: 18 – 23
14 *Weiss H, Düntsch U, Weiss A.* Risiken der Feinnadelpunktion – Ergebnisse einer Umfrage in der BRD (DEGUM-Umfrage). Ultraschall in Med 1988; 9: 121 – 127
15 *Weiss H, Düntsch U.* Komplikationen der Feinnadelpunktion – DEGUM-Umfrage II. Ultraschall in Med 1996; 17: 118 – 130
16 *Livraghi T, Damascelli B, Lombardi C et al.* Risk in fine needle abdominal biopsy. J. Clin. Ultrasound 1983; 11: 77 – 81
17 *Buscarini L, Fornari F, Bolondi L et al.* Ultrasound-guided fine-needle biopsy of focal liver lesions: techniques, diagnostic accuracy and complications. A retrospective study on 2091 biopsies. J. Hepatol 1990; 11: 344 – 348
18 *Buscarini E, Di Stasi M.* Complications of Abdominal Interventional Ultrasound. Milano: Poletto Edizione; 1996
19 *Hancke S, Henriksen FW.* Percutaneous pancreatic cystogastrostomy guided by ultrasound scanning and gastroscopy. Br. J. Surg 1985; 72: 916 – 917

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20 WHO informal Working Group on Echinococcosis. Guidelines for treatmentof cystic and alveolar echinococcosis in humans. Bull World Health Organization 1996; 25: 655 – 689
21 *Solbiati L*, *Giangrande A*, *De Pra L et al.* Percutaneous ethanol injection of parathyroid tumors under US guidance: treatment of secondary hyperparathyreoidism. Radiology 1985; 155: 607 – 610
22 *Livraghi T*, *Paracchi A*, *Ferrari C et al.* Treatment of autonomous thyroid nodules with percutaneous ethanol injection, preliminary results. Radiology 1990; 175: 827 – 829
23 *Livraghi T*, *Festi D*, *Monti F et al.* US-guided percutaneous alcohol injection of small hepatic and abdominal tumors. Radiology 1986; 161: 309 – 312
24 *Buscarini L*, *Fornari F*, *Rossi S*. Interstitial radiofrequency hyperthermia in the treatment of small hepatocellular carcinoma: percutaneous sonography-guidance of electrode needle. In: Anderegg A, Despland PA, Otto R et al. eds. Ultraschall Diagnostik. 91: 1992: 218 – 222
25 *Saitoh M*, *Watanabe H*, *Inaba T et al.* Ultrasonically guided puncture in urology – Transrectal real time linear scanner. Proc. Jpn Soc Ultrasonics Med 1980; 37: 459 – 460 (in Japanese)
26 *Holm HH*, *Gammelgaard J*. Ultrasonically guided preciseneedle placement in the prostate and the seminal vesicles. J Urol 1981; 125: 385 – 387

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