10 USG-guided Puncture in Mini-PCNL

Thomas Knoll and Nabil Atassi

10.1 Introduction

Establishment of the renal access is one, if not the key point in the success of a PCNL [1]. It is achieved by an exact and proper puncture of the collecting system of the kidney. Once established, the success of the procedure in terms of Stone-Free Rate (SFR) and safety can be significantly increased [2]. The use of ultrasonography for access in PCNL was first described in the 1970s. Since then, its efficacy, safety, and feasibility were demonstrated with sufficient literature-based data [3]. Ultrasonography-guided access alone as well as an intraoperative combined ultrasonography–fluoroscopy-guided access implicates the advantage of a more adequate puncture and fewer access-related complications [4]. Regarding ultrasound-guided access, Stone-Free Rates are comparable with the positive effect of a lower complication rate [5–7]. The identification of surrounding organs is possible and nearby eliminates the risk of inadvertent organ injuries [8]. Ultrasonography guidance of the renal puncture has various advantages: It is real time, safe, and rapid in experienced hands, suitable in case of renal failure, as the use of nephrotoxic contrast medium is unnecessary. It is free of radiation for patients including children and pregnant women and operating personnel [9–11]. Ultrasonography-guided access is safe for the experienced surgeon, SFR, and safety increases significantly after a learning curve of a minimum of 20 interventions [12, 13]. During that learning curve of younger surgeons, Ultrasonography-guided access showed to be as well safe and feasible [14]. So, there are a lot of good reasons to perform the puncture of the collecting system as the first step during the intervention by the surgeon itself instead of leaving it to the radiologist as it is common in some countries, considering that there is no significant difference in success between access obtained by either an interventional radiologist or a urologist [15]. Regarding dilatation of the renal tract, few data is available showing that it can be safely performed by ultrasound guidance with equal efficacy and safety compared to fluoroscopic guidance [16]. Disadvantages in ultrasonography-alone guided puncture can be the difficulty to puncture non-dilated collecting systems and sometimes poor visualization of the guidewire and even the puncture needle itself [17]. This problem can be resolved by the placement of a ureteral catheter and injection of saline solution with or without a contrast agent [8, 18]. Latest studies assessed the feasibility of contrast-enhanced ultrasound for non-dilated kidneys in percutaneous nephrolithotomy with promising results that need to be further validated.

T. Knoll (✉) · N. Atassi
Department of Urology, Klinikum Sindelfingen, Böblingen, Germany
e-mail: T.Knoll@klinikverbund-suedwest.de; N.Atassi@klinikverbund-suedwest.de

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10.2 Principles of Ultrasound for Renal Access

Ultrasonography-guided access can be performed safely both in prone and supine positions [19–21]. The safest access to the renal collecting system is a long and posterior lower calyx, as it is at the closest distance to the skin and has less risk of interference with other structures such as surrounding organs [18, 22]. In some cases, due to the location of the stone, an upper-pole puncture might be needed and can also be safely performed by ultrasonography guidance [23]. The first step in preoperative planning of the procedure is to identify the ideal target calyx and to obtain three-dimensional knowledge of the kidney and the stone. It is essential to understand the anatomical location of the kidney: It is located anterior to the psoas muscle, between the 12th thoracic vertebral body and the second/third lumbar vertebral body. Both kidneys are within the retroperitoneum at approximately 30° posterior to the frontal plane of the body (Figs. 10.1 and 10.2). Access to the kidney is always established individually according to the particular anatomy. Frequently, the ribs or the iliac crest limit the space for access. In these cases, the area has to be shifted a few degrees (caudally or cranially 10–20°) [24]. The ideal puncture passes through the extension of a renal calyceal papilla (Fig. 10.1). The puncture site direction is determined to be as close as possible from the calyx to the skin. The procedure may be facilitated by using a diuretic to dilate the calyx [25]. The ultrasonography scanner has to be moved laterally within the defined puncture plane until the access calyx points directly toward the scanner (Fig. 10.3). An electronically generated puncture line (depends on the device used) that indicates in the longer axis of the needle guidance adapter helps find the right puncturing line and angle. It is intended to puncture the avascular zone in the center of the calyx. This is achieved by moving the scanner head laterally on the predefined puncture plane while keeping the scanning plane within the predefined puncture plane (Fig. 10.1). The image will change until the access calyx points directly toward the scanner head (Fig. 10.4). This is the least traumatic and nearly avascular path through

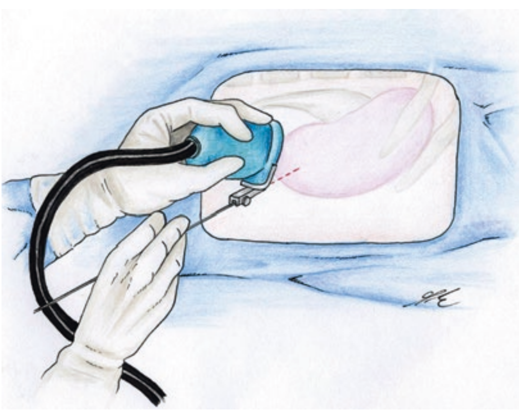

Fig. 10.1 Determination of the puncture site and direction

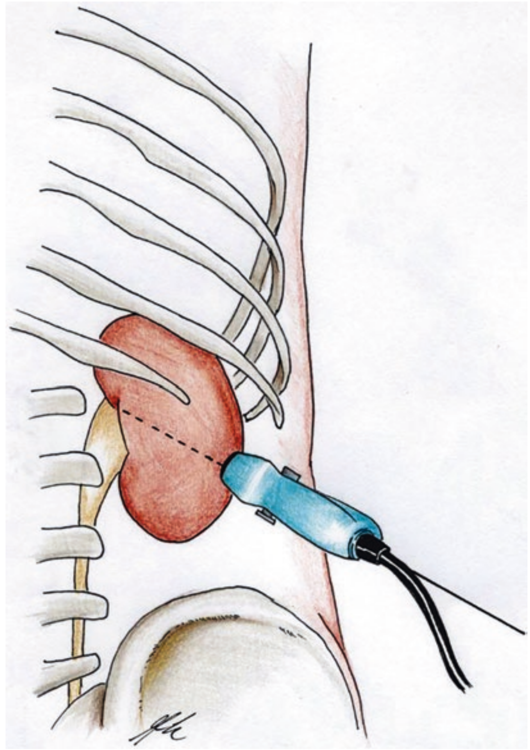

Fig. 10.2 Positioning of the US probe for puncture of the lower calyx

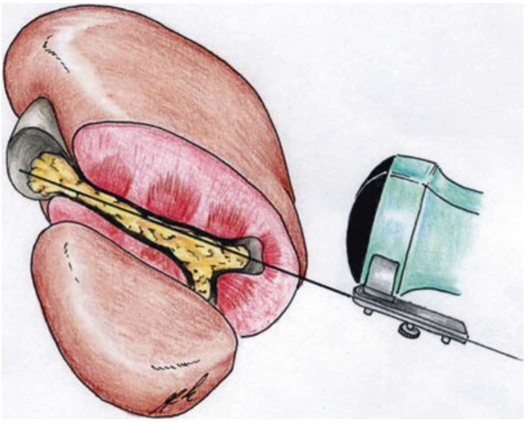

Fig. 10.3 Puncture direction of the needle

Fig. 10.4 Ultrasound picture: Puncture direction of the needle

the kidney parenchyma and the calyx to the renal pelvis [Knoll/Michel et al.]. The use of a needle guidance adapter is not mandatory, a freehand puncture can also be performed. Using the needle guidance adapter may be advantageous for the beginner, but one has to consider, that the needle can be deflected from the predefined path due to different tissue consistencies. Freehand puncture allows easier detection and correction of the needle's direction. To correct the needle's direction, it has to be moved outside the kidney, sometimes even out of the skin. Once the direction of the puncture inside the kidney is defined, it should be finished. The needle can be followed until it reaches the calyx by ultrasound. The success of the puncture can be verified by urine flow through the inner part of the hollow needle. In those the stone completely fills the target calyx, this effect will not appear. The direction of the puncture will then directly target the stone [24]. Haptic confirmation of stone contact can be useful to assure the optimal position of the needle tip. Ultrasonography also allows the use of Doppler Mode to visualize renal vasculature. It can facilitate the needle puncture without causing injury to significant vessels [26]. There also is first data indicating that contrast-enhanced ultrasound (CEUS) could be valuable for percutaneous nephrolithotomy in a non-dilated kidney improving visibility and facilitating the selection of suitable calyx for puncture [27].

10.3 Technique of Combined Ultrasound-fluoroscopy Guided Access

Regarding and interpreting the recent status-quo of available data, the ideal imaging technique in percutaneous access for (Mini-)PCNL seems to be a combination of ultrasonography and fluoroscopic guidance, especially for more complex stones [6, 18]. While simpler stones seem to be accessible with ultrasound-alone guidance with no radiation at all, more complex stone treatment shows better outcomes using a combined access [28]. The combined approach increases the accuracy of the puncture and decreases the radiation exposure for patients, surgeons, and nurses [29]. Practically, determination of the target calyx and puncture plane, puncture site, and puncture direction moves in the long axis of the target calyx: The best way to identify is by fluoroscopy. In particular, an initial puncture under ultrasound guidance in a fluoroscopy suite appears to be the best modality for percutaneous access in percutaneous nephrolithotomy [30]. Especially for inexperienced surgeons during the learning curve, the combined access surely is an additional safeguard to visualize the collecting system with the help of fluoroscopic guidance. The surgeon's experience in any way is fundamental in choosing the best modality for percutaneous access.

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