Ancillary Devices for Percutaneous Nephrolithotomy

M. Binbay, F. Sendogan, and F. Yanaral

Abstract Urolithiasis is one of the most common urologic diseases with an increasing incidence and prevalence. There are various minimally invasive surgical techniques used in the treatment of urolithiasis. Percutaneous nephrolithotomy (PNL) is a well-defined procedure in the treatment of large and complex kidney stones with a high stone-free rate. The main purpose of percutaneous nephrolithotomy, as in all stone surgeries, is to provide complete stone clearance with minimal morbidity. For this, a variety of ancillary devices are employed. In the world of medicine, there are always new innovations and tools making their way to the forefront every year. Technique and instrumentation advances have been made over time to reduce morbidity and increase efficacy in PNL. In this section, we reviewed the ancillary devices used in PNL.

Keywords Urolithiasis · Percutaneous nephrolithotomy · Kidney stone · Ancillary devices

1 Introduction

In 1976, Fernström et al. succeeded in removing stones from the renal pelvis by creating a percutaneous canal, using a nephroscope and a stone basket, and described the PNL technique Fernström and Johansson (1976). This landmark publication paved the way for the development of endourology. From the past to the present, the PNL technique has developed rapidly. Currently, PNL is a well-known, widely accepted and innovative minimally invasive surgical procedure stone removal within urological procedures. The current European Association of Urology guidelines

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recommend PNL as first-line therapy for complex and larger than 2 cm kidney stones Skolarikos et al. (2022).

The main goal of PNL is to achieve maximal stone clearance with minimal morbidity. The key to stone clearance is to use a correct surgical technique and appropriate expertise and instrumentation provided by up-to-date technology. In this section, ancillary devices for PNL surgical steps such as access, tract dilatation, stone fragmentation, stone removal will be discussed.

2 Instruments for Access/Puncture

The optimal access should be planned preoperatively according to the characteristics of the stone, the anatomy of the collecting system, and the location of adjacent organs Yu et al. (2018). Whether in the prone, supine, or modified positions, obtaining adequate access to the renal collecting system is the general principle to performing successful PNL. Imaging modalities are the most important key providing access. However, the ancillary access devices are just as important as the imaging modalities. Ancillary devices providing access in PNL are discussed in this section.

2.1 Needle Holder

During PNL operations, the surgeon's hands are the most exposed to radiation. Needle holder is designed to prevent the hands from being directly exposed to radiation during the puncture procedure. In addition, while accessing under C arm fluoroscopy particularly using bull-eye technique, a much better view is obtained if a needle holder is used as the hands will stay away from the operation area. The silicone insert holds the needle in place while preventing the stylet from backing out of the cannula during introduction. The silicone inserts are designed to accommodate an 18 gauge trocar needle and a 22 gauge Chiba needle.

2.2 Needles

Standard options for an access needle are a 21 gauge and 18 gauge needle. A guide wire of 0.018 inch and 0.035 inch is passed through these needles, respectively. The needles used for accessing the pyelocaliceal system consist of two or three pieces. The central mandrel has oblique edges and exceeds the external sheath in length. After removing the central part, the tip is often cut straight to avoid damaging the wall of the upper urinary tract Mulţescu et al. (2016).

The advantage of the 21 gauge needle is that it causes relatively minor injuries as it passes through tissue. Multiple accesses can be made due to the low risk of needle-related hemorrhage. However, in patients with scarred kidneys or obese patients, the 21 gauge needle does not adequately protect trajectory. A thicker 18 gauge needle should be preferred in these patients. In addition, a 0.018 inch guidewire passing through a 21 gauge needle may not provide sufficient stability for subsequent tract dilatation or catheter placement. In this case it should be replaced with a standard 0.035 inch guidewire. This requires an extra step, which adds to the complexity of the procedure and increases the risk for access failure.

The impact of puncture needles on bleeding complications of PNL is often ignored. Actually, the conventional needle tip used in standard PNL is sharp and can easily injure the renal vessels. In a study by Sampaio et al. reported that the interlobar or segmental artery was injured in 13.6–26.5% of patients in punctures performed with an 18 gauge needle Sampaio et al. (1992). Bleeding risk is less in blunt surgeries due to the elastic structure of major arteries. The majority of devices used in PNL are blunt-tipped due to possible major injuries. Based on these ideas, Hou et al. provided the first proposal of the concept of blunt puncture in PNL. The blunt needle consists of two parts, a blunt needle core and a needle sheath Hou et al. (2022). The tip of the needle core looked like an elongated semi-ellipsoid. The distal end of the needle sheath was designed with dense echo holes, and the needle sheath was marked with a scale line to enable real-time monitoring and allow the depth of needle penetration to be determined by ultrasound (Fig. 1).

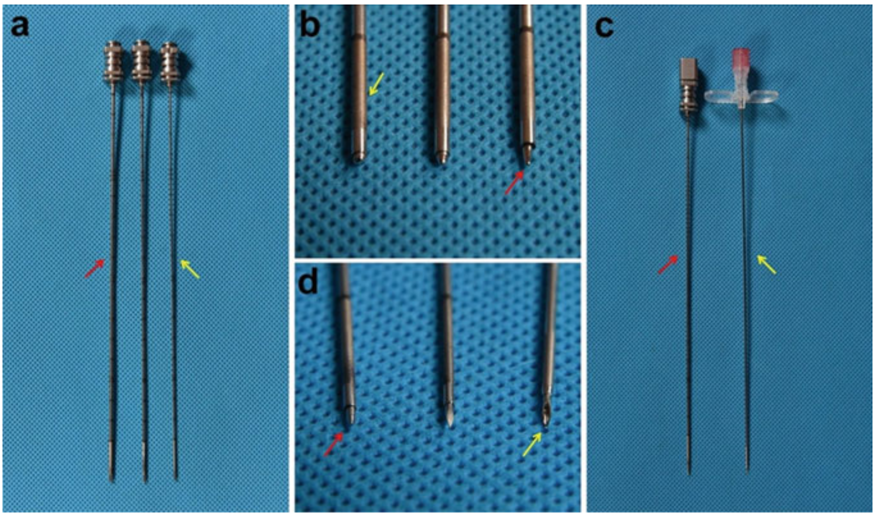

Fig. 1 Characteristics of the needles. **a** 16-gauge (red arrow), 17-gauge and 18-gauge (yellow arrow) needle sheaths. **b** Needle core tips with three different degrees of bluntness (red arrow); echo holes (yellow arrow). **c** The selected blunt needle (red arrow) and conventional needle (yellow arrow). **d** The tips of the selected blunt needle (red arrow), auxiliary sharp needle and conventional needle (yellow arrow)

Visibility of needles differs between fluoroscopy-guided access and ultrasound-guided access. In fluoroscopic access, the needle is only visible during fluoroscopy. Echotip needle provides enhanced visualization of needle tip when used with ultrasonic access Alken (2022). The Echotip needle typically consists of a blunt 1.3 mm diameter cannula with a special grid for enhanced ultrasound reflection and a 1.0 mm diameter stylet with a diamond-shaped cutting tip van Gerwen (2014).

2.3 Guidewires

The usage of guidewires is a cornerstone in the field of endourology. In urology, guidewires are generally used for two main purposes: to access the upper urinary tract and to serve as navigation tools for catheters, stents, ureteral access sheaths, and endoscopes Clayman et al. (2004). Each guidewire is designed with different structural features to perform certain surgical procedures. Guidewires used for percutaneous access traditionally have soft J-shaped ends to reduce the risk of peripheral injury and perforation. The diameters of the guide wires range from 0.018 inches to 0.039 inches. However, thin guide wires can be deformed more easily and cannot navigate to ureter. Therefore, radiopaque hybrid guidewires, combination of hydrophilic flexible tip with stiff nitinol core, are more preferred for initial access to pelvicalyceal system. Hybrid guidewires facilitates passage beyond obstructions and negotiates tortuous anatomy with the hydrophilic flexible tip as well as provides enhanced instrumentation and device placement (Fig. 2). Whole hydrophilic coated guidewires are less frequently used during percutaneous procedures due to the increased risk of extraction or easy displacement. Mulţescu et al. (2016) Loach smooth polytetrafluoroethylene (PTFE) guidewires can be used by surgeons who have cost concerns. However, faulty placement of loach wire is common during percutaneous nephrolithotomy, resulting in incorrect dilation and complications Ding et al. (2023).

Dilation of the puncture tract is usually performed on 0.038–0.039 inch guidewires with increased axial rigidity LeRoy et al. (2006). The Amplatz super-stiff wire® (Boston Scientific Microvasive, USA) is one such example. Amplatz Super Stiff guidewire is made up of PTFE coated superstiff shaft. The rigidity of the flat wire design allows advancement of drive instruments such as dilation catheters and ureteral access sheaths Kolvatzis et al. (2022). In this way, dilatation of the percutaneous nephrolithotomy tract is facilitated.

2.4 Angled Catheters

An angled catheter is often preferred after obtaining access to pelvicaliceal system whenever the guidewire is unable to reach a desired calyx or ureter. It is useful for negotiating the guidewire around an obstructing stone of the calyx or for directing the guidewire towards ureter. Angled catheters are usually designed in single lumen,

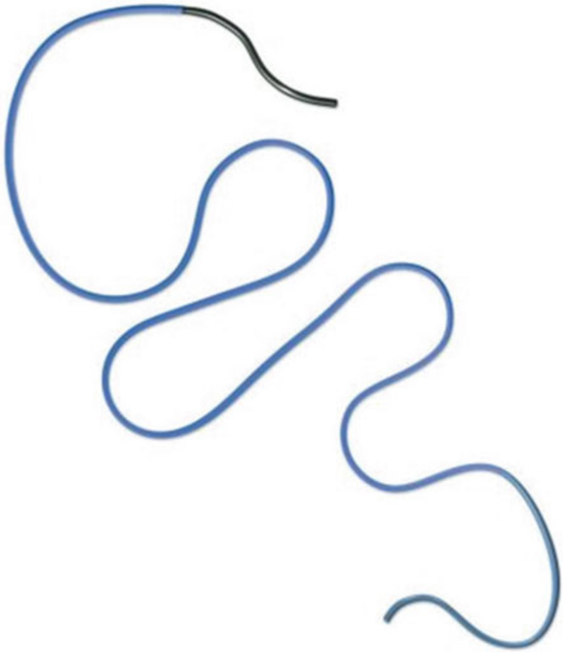

Fig. 2 Sensor® Guidewire (Boston-Scientific Microvasive, USA) is one of the examples of hybrid guidewires

composed of radioopac materials and a 45° angled tip. Kumpe catheter® (Cook Medical, USA) and Imager™ II (Boston Scientific Microvasive, USA) are brand examples of angled catheters.

2.5 Dual Lumen Catheters

A dual lumen catheter is an indispensable instrument in the urologist's toolkit, provides two important functions during percutaneous nephrolithotomy. Firstly, dual lumen catheter is placed in kidney on the guidewire located in the kidney and through the second lumen a contrast media injection system allows the surgeon to accurately visualize the pelvicalyceal system and location of the stone under a fluoroscopic image. Secondly, a safety guidewire can be placed in the pelvicalyceal system where the initial guidewire is located.

3 Dilation Instruments

Tract dilation is one of the crucial steps in PNL, and it is mandatory to create a safe and effective percutaneous tract. Various techniques (Balloon dilation, Amplatz dilation) for establishing a percutaneous tract have been defined. Studies have shown that as tract diameter increases, the probability of bleeding in PNL increases Akman et al. (2011). For this reason, over the years, the technique has evolved to include instruments with smaller tracts. PNL operations are classified as standard, mini, ultra-mini and micro PNL according to the tract diameter created. The surgeon should decide which size tract to use in a balance by considering the patient's stone load, estimated operation time, and the patient's anatomical structure.

3.1 Nephrostomy Balloon Catheter

Nephrostomy balloon dilation catheter is designed for radial dilatation of nephrostomy tract in a single step over a guidewire. Radiopaque marker band on the tip of balloon catheter guides navigation and assure the correct placement. After inflation of balloon to manufacturer's proposed pressure, working sheath is placed under fluoroscopic view. If a balloon dilator is preferred, surgeon should be sure that a high-pressure inflation device is present in the operating room. Kit forms of balloon dilators includes the inflator device.

The use of a balloon catheter shortens the duration of fluoroscopy and dilatation Tepeler et al. (2009). It provides convenience to the surgeon by providing a single-step tract dilation in hypermobile kidneys. On the other hand, in patients who had previous kidney surgeries, balloon dilators could fail to create a tract because of low burst pressure at 17 ATM. In recent years, this problem has been solved with the introduction of new nephrostomy balloon catheters that apply higher inflation force up to 20–30 atm pressure (Fig. 3).

Different sizes of balloon catheters (18Fr, 24 Fr, 30Fr) and catheters with longer balloon and working sheath length for obese patients are available in the market. Renal sheath is available in PTFE and Clear materials. Clear Renal Sheath facilitates visualization of calculi surrounding the sheath.

3.2 Amplatz Type Renal Dilator

The Amplatz Renal Dilator is a set of firm dilators, used for sequential dilatation of the nephrostomy tract. The Amplatz Renal Dilator works by progressively expanding the desired calyces. Initially 8 Fr stylet is placed in the pelvicalyceal system over the guidewire; following progressive dilation is performed over 8 Fr stylet. Graduated dilator set includes 12 dilators (8F to 30F) and 8 Fr stylet. The Amplatz Renal Dilator

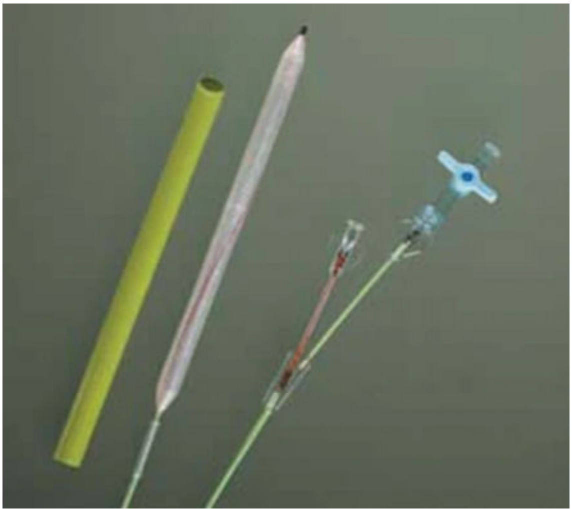

Fig. 3 X-Force® N30 high pressure nephrostomy balloon catheter

Fig. 4 Different sizes of Amplat sheath dilators and percutaneous access sheaths

set also includes various sizes of Amplatz sheaths from 24 to 30 Fr (Fig. 4). Moreover, smaller sizes Amplatz sheaths from 14 to 24 Fr is available in the market. The diversity in dilator sizes allows for individualized dilatation, considering anatomical characteristics of the patients and stone size.

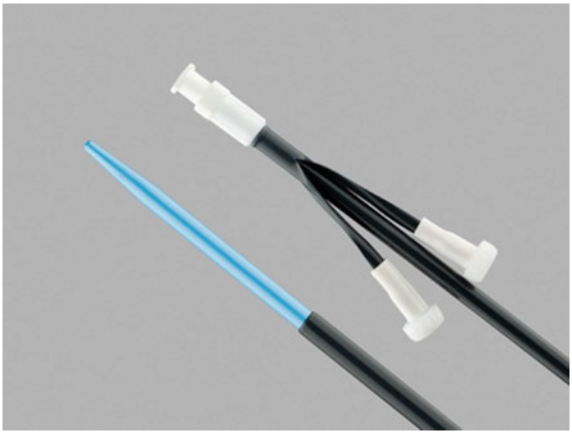

Fig. 5 Peel-Away® Introducer Set

3.3 Peel Away Introducer

Another option in tract dilation has been the introduction of the pathway access sheath (PAS), a device that allows for tract dilation and sheath placement at the same time for mini PNL. Peel Away introducer has a 32 cm, relatively longer working sheath. Various diameters of Peel-Away® Introducer (Cook) in 9 Fr, 10 Fr and 12 Fr are available in the market (Fig. 5).

4 Stone Extraction Instruments

Many ureteroscopic instruments are especially applicable to PNL when a flexible scope is inserted; however, percutaneous access also enables various unique stone-removal techniques. During the procedure, a variety of stone instruments are used to effectively remove the stones. Stone extraction baskets and stone-grasping forceps are the tools used in PNL for stone extraction. They can be rigid (thicker and more robust) or flexible (typically of a lower caliber and imply more fragile). The flexible ones can be used on flexible as well as rigid nephroscopes. In comparison to the retrograde approach, the flexible nephroscope with wider working channel allows for the insertion of instruments of a higher caliber, which are both more durable and more effective at extracting stones.

4.1 Forceps

Alligator forceps, tripod (or tetrapod) graspers, and smooth graspers are the three main types of rigid extractors. The profile of the alligator forceps' jaws allows for

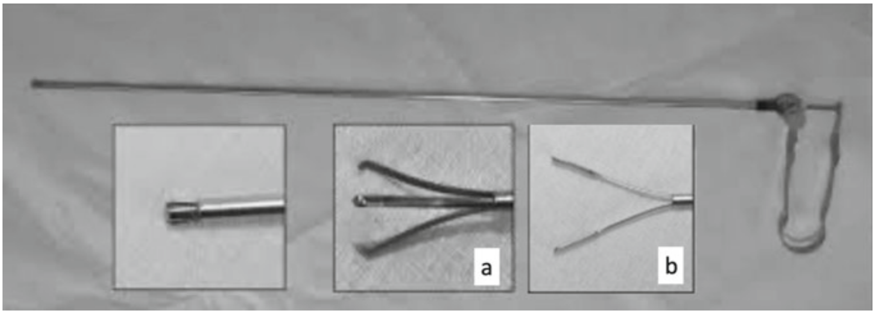

Fig. 6 Tripod grasper (a) and grasper with smooth jaws (b)

a firm hold on the stone fragments. However, because of the scissors-like way they open, they need space around the stones, and if more pressure is put on the actioning mechanism, it becomes relatively brittle. The jaws' significant force makes it possible for stones with a reduced consistency to fragment uncontrollably. Alligator graspers with curved jaws that define a small space between them can be used for these kinds of stones.

Tripod graspers have three sturdy arms with curved, claw-like ends (Fig. 6). They are among the most effective extracting tools, having a firm hold on the fragments while only requiring a small opening space. The walls of the pyelocaliceal system can be easily penetrated by the arms' thin and rough ends, though. Additionally, there are four-arm graspers, which are thought to be less effective.

Smooth graspers rarely manage to get a strong grip. Additionally, their full opening implies that they protrude from the extractor's working channel and exterior sheath, which is another reason it must be done carefully to avoid damaging the tissues. A movement of anteriorly pushing the instrument must be combined with that of closing the jaws, as in the case of the tripod, to ensure that the stone is caught.

The distal portion of a basket probe and a grasper's actioning mechanism are combined in the Cook Medical Perc N Circle®. Squeezing a handle causes a lightweight 10 F probe to release a 2 cm, tipless basket. The tipless design of the Perc NCircle is positioned directly against the mucosal lining with minimal trauma. In bleeding cases Perc NCircle is a unique instrument for safely removal of blood clots. Perc NCircle® has a special design, opening the basket with an angle of 45° allows to safely collect small stones in the calyx that cannot be reached with a rigid nephroscope. A tripod grasping forceps and the Perc NCircle were compared, and it was discovered that the Perc NCircle had a quicker stone extraction time. Additionally, it was linked to a lower chance of dislodging the percutaneous access sheath Hoffman et al. (2004). Subsequently, the Perc N Compass and Perc N Gage, which have different basket models, have been added to the Perc extractor line (Fig. 7).

The PerkX Stone Extractor (Rocamed) is a 10 Fr basket catheter with nitinol 4 wires and a tipless design. Its ergonomic handle and Tuohy Borst connected design allow for efficient insertion of a 272μm fiber. The tipless basket of PerkX enables direct positioning against the mucosal lining during procedures. It offers both stone

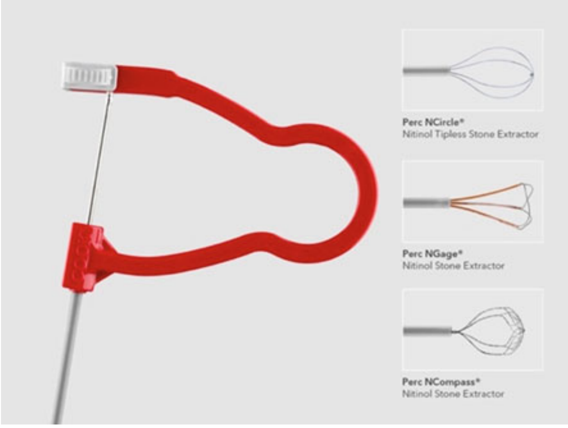

Fig. 7 Perc nitinol stone extractors

fixation and laser lithotripsy, with the possibility for stone displacement particularly in hydronephrotic systems.

Graspers are good for obtaining a strong grip on stones and for removing large fragments. However, they can be difficult to use in smaller spaces and may cause tissue damage. Baskets, on the other hand, are useful for capturing small stones and fragments. They are gentle on tissue and cause less trauma. However, they are not as effective at gripping larger stones and may cause fragmentation.

4.2 Basket Catheters

Basket catheter, also known as a stone retrieval basket, is a small wire mesh device designed to capture and remove stone fragments. There are different types of basket catheters used in PNL. Old baskets were made of stainless steel and could be reused. Nitinol, a metal alloy made of titanium and nickel, is used in modern baskets so that the surgeon can remove stones more successfully and with less trauma. They are all single-use, and due to their various sizes, shapes, and designs, the surgeon can use them in different situations. 4.5 French baskets are utilized in larger scopes with wider working channels, such as flexible cystoscopes and mini-nephroscopes. Tipped baskets are not preferred for PNL as tip of the basket may damage the urothelial lining and cause bleeding.

There are two different categories of baskets for PNL: tipless baskets and special design baskets.

Tipless Baskets

They are typically made of four nitinol wires with twisted or flower design to increase the radial dilating force while minimizing trauma to the urothelium. In addition, they frequently have the ability to alter the calyx's shape and access stones that may be just beyond the endoscope's tip's reach. They are the most widely used across the globe because of the design, which enables the surgeon to use it in a variety of settings without risking a traumatic tip effect. French sizes range from 1.3 to 4.5.

Bard (1.9/2.4/3.0 Fr), Boston Scientific (1.9/2.4/3.0 Fr), Cogentix Medical/ Laborie (1.3/1.9/2.2 Fr), Coloplast (1.5/2.2/3 Fr, twisted wire with flower design), Cook (1.5/2.2/3.0/4.5 Fr), Olympus (1.8/2.2/3.0 Fr, twisted wires to maintain shape, rotation control handle), Sacred Heart (1.5/2.4 Fr, with rotation control handle) are the manufacturers of 4-wire round tipless baskets. There are also manufacturers of unique tipless baskets, such as Olympus (1.8/2.2/3.0 Fr, cross-paired wires for increased radial dilating force, rotatable handle) and Sacred Heart (1.5 Fr, 6-wire round).

There are some front-opening, tipless special baskets. These baskets are useful in some situations where the surgeon wants to catch the stone from the front with wires closing from the laterals. When you are in front of the stone and want to simply catch and release it (for instance, to move it from the inferior to the superior calyx), this is incredibly helpful. French sizes are range from 1.7 to 2.2. Manufacturers of tipless end engaging baskets include Cook (1.7/2.2 Fr) and Boston Scientific (1.9 Fr, OpenSure handle capable of secondary opening to ensure release).

Special Design Baskets

There are also some special design baskets. Bard has 2.4/3.0 Fr baskets with articulated basket position at handle. The 2.6/3.3 Fr basket from Boston Scientific has serrated nitinol wire edges and is shaped like a grasping forceps. Cook's 1.5/2.4 Fr basket has a 16-wire mesh construction that is intended for retrieving small stone fragments. It is recommended that urologists who frequently perform endoscopic stone surgery to have a variety of stone extraction instruments in their armamentarium.

5 Instruments for Preventing Complication

5.1 Ureteral Occlusion Device

Ureteral occlusion devices are used during percutaneous nephrolithotomy (PNL) to prevent the migration of stone fragments into the ureter and to facilitate stone clearance. These devices can be used when there is a risk of larger stone fragments being created during the PNL or when there is concern that smaller fragments may migrate into the ureter and cause obstruction. By blocking the ureter, the catheter allows for the safe use of nephroscopy and laser lithotripsy. The catheter is typically removed at the end of the PNL procedure.

Ureteral occlusion balloons are inflatable devices typically made of silicone or latex, which are temporarily placed within the ureter to block its lumen. Once inflated, the balloon prevents stone fragments from passing into the ureter. It is important to note that the choice of an occlusion device depends on several factors, including the size and location of the stone, the patient's anatomy, and the surgeon's experience and preferences. Additionally, not all PNL procedures require the use of ureteral occlusion devices, and their use may be determined on a case-by-case basis.

There are several types of ureteral occlusion balloons available in the market: Cook Ureteral Balloon Catheter, Bard Ureteral Balloon Catheter, Boston Scientific Occluder™ Occlusion Balloon Catheter, Coloplast Ureteral Balloon Catheter, Teleflex Ureteral Catheter, Olympus Balloon Catheter (Fig. 8).

There are advantages and disadvantages to the use of ureteral balloon occlusion devices. The device can be placed quickly and is easy to use. It reduces the risk of stone migration by providing good occlusion. Whereas the balloon may cause irritation or injury to the ureter or renal pelvis. There is a risk of balloon rupture, which can lead to complications. In some cases, it may be difficult to achieve adequate occlusion with the balloon device.

While the types of ureteral occlusion balloons used in PNL are not directly compared, the studies show that the success of the ureteral occlusion balloons used in PNL is related to the size of the stones. A review article published in 2021 provides guidance on the optimal use of ureteral occlusion catheters based on patient and stone characteristics, as well as the surgeon's preference and experience Sadiq et al. (2021).

Fig. 8 Boston scientific occluder™ occlusion balloon catheter

The importance of careful patient selection, appropriate catheter placement, and close intraoperative monitoring to minimize the risk of complications was emphasized by the authors. The decision should be made after careful consideration of the risks and benefits.

Another occlusion device is the Accordion Stone Management Device, a microcatheter-based tool with a hydrophilic coating that creates an occlusion to stop stone fragments from being retropelled. During ureteroscopic lithotripsy, its effectiveness at preventing retrograde fragment migration has been well described Ahmed et al. (2009). Retrospective evaluating of the Accordion®'s capacity to stop antegrade stone migration during PNL was conducted by Wosnitzer et al. (2009). Comparatively, 17 patients (57%) in the control group and 13 patients (43%) in the Accordion® group needed ureteral stenting (there is a statistically significant difference). This device is comparable to the majority of conventional ureteral balloon occlusion devices and appears to be effective in preventing stone migration. However, it is unknown if this device increases stone free rates.

5.2 *Tamponade Balloon Device*

Serious bleeding requiring blood transfusion is seen 3–20% of PNL cases. Since most of the bleedings are due to venous injuries, applying pressure on the percutaneous tract would undoubtedly control the bleeding.

Kaye tamponade balloon device is an instrument produced by Cook company. It is a 14 Fr radiopaque balloon catheter; 15 cm length balloon reaches 12 mm (36 Fr) diameter when inflated. The balloon is able to withstand an inflation pressure of 2.5 atm.

In case of serious hemorrhage from the percutaneous tracts 18Fr or larger, placing a Kaye tamponade balloon catheter not only immediately tamponades the nephrostomy tract but effectively drains the renal pelvis, while maintaining ureteral access.

6 Conclusion

PNL is one of the most important options in the treatment of kidney stones. Nowadays, PNL is performed with high success and lower complication rates due to newly developed techniques, combining different types of surgery, and increasing experience among urologists. The use of high quality and advanced products in PNL surgeries, as well as the fact that urologists know which product to use at what stage is one of the subjective criteria affecting the safety of surgery.

References

Ahmed M, Pedro RN, Kieley S, Akornor JW, Durfee WK, Monga M. Systematic evaluation of ureteral occlusion devices: insertion, deployment, stone migration, and extraction. Urology. 2009;73(5):976–80.

Akman T, Binbay M, Sari E, Yuruk E, Tepeler A, Akcay M, Muslumanoglu AY, Tefekli A. Factors affecting bleeding during percutaneous nephrolithotomy: single surgeon experience. J Endourol. 2011;25(2):327–33.

Alken P. Percutaneous nephrolithotomy—the puncture. BJU Int. 2022;129(1):17–24.

Clayman M, Uribe CA, Eichel L, Gordon Z, McDougall EM, Clayman RV. Comparison of guide wires in urology. Which, when and why? J Urol. 2004;171(6 Pt 1):2146–50.

Ding X, Hou Y, Wang C, Wang Y. Super-stiff guidewire or loach guidewire during percutaneous nephrolithotomy? BJU Int Compass. 2023. https://doi.org/10.1002/bco2.219.

Fernström I, Johansson B. Percutaneous pyelolithotomy: a new extraction technique. Scand J Urol Nephrol. 1976;10(3):257–59.

Hoffman N, Lukasewycz SJ, Canales B, Botnaru A, Slaton JW, Monga M. Percutaneous renal stone extraction: in vitro study of retrieval devices. J Urol. 2004;172(2):559–61. https://doi.org/10.1097/01.ju.0000129195.71871.17.

Hou B, Wang M, Song Z, He Q, Hao Z. Renal puncture access using a blunt needle: proposal of the blunt puncture concept. World J Urol. 2022 Apr;40(4):1035-1041

Kolvatzis M, Sierra A, Corrales M, Traxer O. Stiff guidewires in endourology: What ıs stiffness? J Endourol. 2022;36(11):1475–82.

LeRoy AJ, second edition. Percutaneous access, tract dilation, and maintenance of the nephrostomy tract, 2nd ed. Hamilton, London: BC Decker Inc.; 2006, p. 107–15.

Mulţescu R, et al. Equipment and instruments in percutaneous nephrolithotomy, in percutaneous surgery of the upper urinary tract. Elsevier; 2016. p. 3–24.

Sadiq AS, Atallah W, Khusid J, Gupta M. The surgical technique of mini percutaneous nephrolithotomy. J Endourol. 2021;35(S2):S68–74.

Sampaio FJ, et al. Intrarenal access: 3-dimensional anatomical study. J Urol. 1992;148(6):1769–73.

Skolarikos AAN, Petřík A, Somani B, Thomas K, Gambaro G, Davis NF, Geraghty R, Lombardo R, Tzelves L. EAU guidelines on urolithiasis; 2022. ISBN 978-94-92671-16-5.

Tepeler A, Binbay M, Yuruk E, Sari E, Kaba M, Muslumanoglu AY, Tefekli A. Factors affecting the fluoroscopic screening time during percutaneous nephrolithotomy. J Endourol. 2009;23(11):1825–9.

van Gerwen DJ, Dankelman J, van den Dobbelsteen JJ. Measurement and stochastic modeling of kidney puncture forces. Ann Biomed Eng. 2014;42(3):685–95.

Wosnitzer M, Xavier K, Gupta M. Novel use of a ureteroscopic stone entrapment device to prevent antegrade stone migration during percutaneous nephrolithotomy. J Endourol. 2009;23(2):203–7.

Yu X, Xia D, Peng EJ, Yang H, Li C, Yuan HX, Cui L, Wu BL, Zhang JQ, Wang S, Wei C, Ye ZQ, Wang SG. Clinical investigation of ultrasound-guided percutaneous nephrolithotomy accessed by SVOF-principle and two-step puncture techniques. Zhonghua Wai Ke Za Zhi. 2018;56(10):764–67.