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MINI-REVIEW

Training the resident in percutaneous nephrolithotomy

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ABBREVIATIONS

PCNL, percutaneous nephrolithotomy;
US, ultrasonography;
VR, virtual reality;
PCS, pelvicalyceal system;
EBM, evidence-based medicine

Abstract ***Objective:*** From the trainers' perspective percutaneous nephrolithotomy (PCNL) is one of the most challenging endourological procedures. In this review we examine the problems arising when training residents in PCNL, and how to facilitate this process.

Methods: The recommendations are derived from discussions and consensus during the First European Urolithiasis Society (EULIS) meeting held in London in September 2011. In addition, we searched Medline for articles identified using the keywords 'training', 'percutaneous surgery', 'renal calculi', 'PCNL', 'virtual reality' and 'simulators'. We also assessed the effect of modern technology, including the availability of virtual reality models vs. operating room training, and how international organisations like EULIS and European Urological Association can help.

Results: The difficulty of training residents in PCNL is partly due to the complexity of obtaining a safe access to the kidney for lithotripsy. The most common way of obtaining access is guided by imaging only, and usually only fluoroscopic imaging is available. This has the potential for injuring structures from the skin to the renal capsule. Minor vascular injuries are relatively common, although most

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are self-limiting. Visceral injuries that are particularly important are pleural and less commonly colonic injuries, but they are more complex and often require additional procedures.

Conclusions: Teaching the skills is more challenging than performing PCNL. In most urological training programmes it is difficult to incorporate teaching and training skills when performing PCNL. To train an academic stone doctor, proficiency in the safe conduct of PCNL is mandatory.

Introduction

Most renal stones of < 20 mm in diameter are treated by ESWL or by retrograde intra renal surgery, although this is being challenged by 'micro' percutaneous nephrolithotomy [1] (PCNL), However, standard PCNL has become the single most common interventional tool in the management of larger renal stones.

Training for PCNL during a residency is essential to familiarise the trainee in this complex procedure. In a recent report from the UK [2] the exposure of residents to various urological procedures was examined, noting that trainees performed, or performed under supervision, a mean (range) of only 19 (0–125) PCNLs during their training. The authors also noted that there was significant variability amongst the trainees. Access to the kidney for PCNL is critical to the successful removal of the stone and is often made by a specialist other than a urologist, particularly in academic centres [3]. Once qualified, most of the trainees work in places where there is a limited availability of such interventionists. It is therefore imperative that residents should be trained in gaining access, as well as in stone fragmentation and retrieval.

The need for training residents in PCNL

The management of large renal stones has changed significantly from open surgery to ESWL and percutaneous surgery in the last quarter of a century [4,5]. The indications for ESWL have been refined in view of the experience gained. Laparoscopic pyelolithotomy [6] and in selected cases ESWL, particularly in children, is also used for large renal stones, but PCNL remains the standard of care, with ESWL as salvage treatment for small residual fragments.

Training in PCNL involves developing expertise in gaining access to the kidney, but also in stone fragmentation and intracalyceal navigation, and stone scavenging and fragmentation. The steep learning curve is mainly related to obtaining renal access [7]. The fear of injuring structures during a 'blind' approach up to the renal capsule is a major concern. This is partly overcome by using ultrasonography (US) and more recently by using a 4.85 F 'all-seeing' needle [8] (PolyDiagnost™, Pfaffenhofen, Germany). The intracalyceal course is helped by simultaneous ureteroscopic access [9]. This has the advantage of a lower radiation exposure, faster surgery and providing an option to gain access in patients with an undilated intrarenal collecting system. However, the lack of universal availability, limited experience and cost are major limiting factors for these technologies.

In a survey conducted in the USA in 2000 [10], most urologists recommended PCNL for staghorn stones, but how many of these urologists performed PCNL themselves was not assessed, and if they are not doing PCNL, why that was the case. In an interesting report, Bird et al. [11] conducted a survey among American urologists trained in PCNL during their residency. They noted that these urologists were more comfortable in managing appropriately large renal stones, although most of them did not make the percutaneous access, which is considered an integral part of the procedure. More recently Spann et al. [12] noted that access for PCNL surgery can be made safely and successfully by urology residents under the supervision of trained staff. Those authors believed that a teaching institution provides the ideal setting in which to instruct the urology resident in this valuable skill. To maximise patient care and success in the operating room, access for PCNL should be taught to all residents before graduation. An interventional uro-radiology unit in an institution is extremely valuable to the residents for developing expertise in renal access. Residents in urology could have a short rotation in the interventional uro-radiology units to develop greater familiarity with the use of US, and to identify not only the kidney but also pararenal tissue, to make safe and effective access during PCNL.

Tools for technical expertise – the role of training models

Knowing the complexity and potential serious complications of PCNL, a more structured training for PCNL should be provided for trainees or junior fellows before they start using the procedure in patients [13]. The use of various training models, as in other branches of medicine, has provided a safer and more repeatable training opportunity for junior staff. There

are various types of models available for PCNL training, including the 'dry laboratory' (inanimate models or mannequins), the 'wet laboratory' (animal models) and the virtual reality (VR) models.

Inanimate or mannequin models are the simplest for PCNL training. Most of these models consist of a kidney model (with a pelvicalyceal system, PCS) embedded in a plastic block. Artificial stones or stone fragments from patients can be implanted into the PCS, which is then filled with saline. Using these models, trainees can practise locating and creating an access under US or fluoroscopy guidance. They can also practice track dilatation over the plastic block, and lithotripsy within the PCS. The advantages of these mannequins include their simplicity and relatively low cost.

Such models provide a good opportunity for trainees to familiarise themselves with handling various tools for PCNL, but the lack of real tissue feeling during access creation and track dilatation might affect the actual performance in real-life situations.

Ex vivo animal models have been used for PCNL training. Kidneys and part of the body wall of freshly slaughtered pigs are used [14]. The renal pelvis is then filled with renal stones via a pyelotomy and closed with a suture. The distal ureter is then tied over a ureteric catheter to allow the instillation of normal saline or contrast medium. Trainees can then practise a percutaneous procedure with the usual approach, under US or fluoroscopic guidance, over the abdominal wall side. This model can provide a tactile sensation comparable to the real-life situation. However, the cost and time required to prepare the model can limit its availability for usual routine practice.

VR simulators consist of a computer-generated environment that mimics the real clinical situation. It has the advantages of being simple to use, a repeatable procedure with a wide range of pre-set clinical scenarios for different levels of training, measurable variables for the assessment and monitoring of the trainee, etc. Therefore, they are becoming increasingly popular in medical training. There are several VR stimulator models available for urological procedures, with the PERC Mentor™ (Simbionix, USA) especially designed for PCNL training [15]. The PERC Mentor consists of various clinical scenarios for training in PCNL under fluoroscopy guidance, in both normal and obese subjects. The system can mimic various procedural steps, including injection with contrast medium via a ureteric catheter, two-plane fluoroscopic visualisation of the PCS, and respiratory control during the puncture.

The simulator can also allow the trainer to pre-set a series of scenarios for a particular training programme. Moreover, the system also provides data on several variables, e.g., the procedure time, fluoroscopy time, and number of attempts. This information is important for assessing the competence and progress of the trainees during their training. However, cost is still the major obstacle to the widespread use of these models.

Training programmes

The success of a simulation training programme does not rely solely on the simulators/models, but also on the careful planning of the system and training programme [15]. A careful planning of training facilities, manpower (trainers), financial funding and training programme design (including theory and practical teaching) are all crucial to maintain a long-term, sustainable and effective programme.

Minimising the effect of differences in the availability of infrastructure, expertise and other resources

Expensive medical services can be offered inexpensively through the appropriate management of alternative methods [16]. Undoubtedly, technological advances have been a valuable assistance in promoting quality and precision in the field of medicine. However, the application of advanced technology can require additional financial resources that might not be available in all countries, especially those with a low gross national product. PCNL, like all medical services, requires that a few fundamental requirements are met, and a brief account of which, along with relevant alternatives, is presented below.

Infrastructure

Although there are some reports of PCNL in patients under local anaesthesia [17] it is mostly conducted under general anaesthesia. PCNL should be used in an ambulatory surgery facility or an operating theatre. Nevertheless, a specific PCNL operating room is not necessary; instead, a section of a general theatre can be equipped for performing the procedure. Hence, urologists should be trained in the spatial requirements so that they can independently determine an appropriate place in a medical centre. In some selected patients ambulatory PCNL could also be considered [18].

Advanced equipment like a nephroscope set (for PCNL), a ureteroscope (8 F), a stone punch and pneumatic lithotripter system [19] can facilitate the procedure and the task of the surgeon, but urologists can be encouraged to make innovations by combining a few devices, and not need all, to perform the whole procedure. For instance, the puncture is made using US guidance instead of C-arm fluoroscopy in some centres [20,21]. Moreover, specific devices with a particular application should be available in a few referral centres, e.g. a laser for disintegrating hard stones.

The principal member of a PCNL team is the trained urologist who conducts the surgery. Therefore, faculty

exchange programmes amongst universities of neighbouring countries with minimal financial and logistics requirements can be arranged. Another cost-effective method is training representatives of centres, or even of countries, in eligible centres, and they can then take the responsibility of training other specialists after returning home.

Financial resources should be maintained through different channels. Governmental budgets should be allocated for the said healthcare service. However, due to the common restrictions in this area, private financial assistance can be a supplement in countries with limited financial sources. Charitable organisations can have an important role in promoting the required facilities. Combining these economic sources can also lead to financial self-sufficiency in sustaining the requirements for PCNL.

In some special conditions, like countries with a low gross national product, providing even the minimum requirements might not be possible. Therefore, international medical societies can contribute to these underprivileged countries by holding specific intensive training courses for their urologists until they are sufficiently skilled to start training their trainees in the home nation. Prosperous countries can also contribute to these societies by providing appropriate venues, e.g., low-price facilities in their countries, to expedite and ease the process of training.

The use of biological training models that simulate realistically the clinical procedure of PCNL under US and fluoroscopic guidance can help in teaching and acquiring the skills [22].

The role of international organisations

At present the important factor in any health profession is the performance in clinical practice. The important test of the credibility and growth of this profession is the ability of a clinician to obtain consistent results in the treatment of patients (what happens and why). How to ensure that a clinician achieves consistent, predictable and reliable results with successive treatments and patients is paramount. The key is research and training. All professions progress, change, obtain credibility and improve based on the research they conduct and produce, and their ability to implement new knowledge into daily clinical practice. From this subtle interaction between research and clinical practice comes the 'academic stone doctor'.

What is an 'academic stone doctor'? It can be claimed that an academic doctor is one who transforms evidence into clinical practice, i.e., using evidence-based medicine (EBM). According to Sackett et al. [23], '*EBM is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients*'. To practise EBM requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research. 'Individual clinical expertise' means 'the proficiency and judgement that individual clinicians acquire through clinical experience and practice'. Increasing expertise is apparent by an effective and efficient diagnosis, and the thoughtful identification and compassionate consideration of each patient's predicaments, rights and preferences. 'Best available external clinical evidence' is clinically relevant research, often from basic sciences, but especially from patient-centred clinical research into; (1) the accuracy and precision of diagnostics; (2) the power of prognostic markers; and (3) the efficacy and safety of therapeutic, rehabilitative and preventive regimens [21]. Good 'academic stone doctors' use both individual clinical expertise and the best available external evidence. Neither alone is enough. Without current best evidence, the practice risks becoming rapidly out of date, to the detriment of patients. However, without clinical expertise, the practice risks becoming tyrannised by evidence, as even excellent external evidence might be inapplicable to or inappropriate for an individual patient. This is especially true when dealing with urolithiasis. Much of the daily clinical practice in the field of stone disease is not supported by randomised trials and meta-analyses. This is not an expression of low research activity within this field, but rather an expression of the difficulties in designing meaningful trials that reflect daily clinical practice, due to the great variability of stone disease, e.g., in stone burden, stone composition, renal anatomy and patient body habitus. In this context, sharing knowledge on clinical practices ('tips and tricks') between practising stone clinicians becomes especially important, and the most effective way that tips and tricks can be promoted to an academic sphere is through the international exchange of knowledge. It is here that international urolithiasis organisations have a significant role, by making forums for the transfer and development of clinical expertise. Appreciating that this transfer of 'tips and tricks' is especially important for stone disease, organisations like EULIS have devoted much energy to arranging international Fellowships, observerships, courses, workshops and master classes, to effectively disseminate new developments for the benefit of patients worldwide. However, the use of tips-and-tricks technology ultimately also needs to be evidence-based, because when asking questions about therapy clinicians should try to avoid the anecdotal approaches, as these often lead to false-positive conclusions about efficacy [21]. In this respect, international organisations are crucial, by connecting clinical experts and trainees in a developmental atmosphere, creating opportunities for controlled multicentre studies to answer questions that cannot be answered through single-centre studies. In this way training might be academic and with an evidence-based perspective; the important factor is integrating individual clinical expertise and the best external evi-

dence [21]. For this integration, the international organisations have a special responsibility in the training of the academic stone doctor.

Conclusions

- The urological resident should be trained in PCNL during the residency period.
- Residents must be trained in both pelvicalyceal navigation and in obtaining calyceal access.
- Careful planning of the training facilities, manpower (trainers), financial funding and training programme design (including theory and practical teaching) are all crucial to maintaining a long-term, sustainable and effective programme.
- Constraints in infrastructure and resources can be overcome by innovative means.
- International organisations like EULIS and the EAU can have a pivotal role in training residents in complex urolithiasis surgery.

Conflict of interest

None.

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References

[1] Armagan A, Tepeler A, Silay MS, Ersoz C, Akcay M, Akman T, et al. Micropercutaneous nephrolithotomy in the treatment of moderate-size renal calculi. *J Endourol* 2013;**27**:177–81.
[2] Gill JD, Stewart LF, George NJ, Eardley I. Operative experience of urological trainees in the UK. *BJU Int* 2012;**109**:1296–301.
[3] Aslam MZ, Thwaini A, Duggan B, Hameed A, Mulholland C, O'Kane H, et al. Urologists versus radiologists made PCNL tracts: the UK experience. *Urol Res* 2011;**39**:217–21.
[4] Ather MH, Paryani J, Memon A, Sulaiman MN. A 10-year experience of managing ureteric calculi: changing trends towards endourological intervention – is there a role for open surgery? *BJU Int* 2001;**88**:173–7.
[5] Ather MH, Buchholz NP. Open stone surgery in 2013. *Eur Urol Today* 2013;**25**:24.
[6] Al-Hunayan A, Khalil M, Hassabo M, Hanafi A, Abdul-Halim H. Management of solitary renal pelvic stone: laparoscopic retroperitoneal pyelolithotomy versus percutaneous nephrolithotomy. *J Endourol* 2011;**25**:975–8.
[7] de la Rosette JJMCH, Laguna MP, Rassweiler JJ, Conort P. Training in percutaneous nephrolithotomy – a critical review. *Eur Urol* 2000;**54**:994–1003.
[8] Bader MJ, Gratzke C, Seitz M, Sharma R, Stief CG, Desai M. The All-Seeing Needle. Initial results of an optical puncture system confirming access in percutaneous nephrolithotomy. *Eur Urol* 2011;**59**:1054–9.
[9] Kawahara T, Ito H, Terao H, Yoshida M, Ogawa T, Uemura H, et al. Ureteroscopy assisted retrograde nephrostomy: a new technique for percutaneous nephrolithotomy (PCNL). *BJU Int* 2012;**110**:588–90.
[10] Hollowell CM, Patel RV, Bales GT, Gerber GS. Internet and postal survey of endourologic practice patterns among American urologists. *J Urol* 2000;**163**:1779–82.
[11] Bird VG, Fallon B, Winfield HN. Practice patterns in the treatment of large renal stones. *J Endourol* 2003;**17**:355–63.
[12] Spann A, Poteet J, Hyatt D, Chiles L, DeSouza R, Venable D. Safe and effective obtainment for percutaneous nephrolithotomy by urologists: the Louisinia University experience. *J Endourol* 2011;**25**:1421–5.
[13] Ahmed K, Amer T, Challacombe B, Jaye P, Dasgupta P, Khan MS. How to develop a simulation programme in urology. *BJU Int* 2011;**108**:1698–702.
[14] Strohmaier WL, Giese A. Improved ex vivo training model for percutaneous renal surgery. *Urol Res* 2009;**37**:107–10.
[15] Ahmed K, Jawad M, Dasgupta P, Darzi A, Athanasiou T, Khan MS. Assessment and maintenance of competence in urology. *Nat Rev Urol* 2010;**7**:403–13.
[16] Zarrabi AD, Conradie JP, Heyns CF, Scheffer C, Schreve K. Development of a computer assisted gantry system for gaining rapid and accurate calyceal access during percutaneous nephrolithotomy. *Int Braz J Urol* 2010;**36**:738–46.
[17] Aravantinos E, Karatzas A, Gravas S, Tzortzis V, Melekos M. Feasibility of percutaneous nephrolithotomy under assisted local anaesthesia: a prospective study on selected patients with upper urinary tract obstruction. *Eur Urol* 2007;**51**:224–7.
[18] Shahrour W, Andonian S. Ambulatory percutaneous nephrolithotomy: initial series. *Urology* 2010;**76**:1288–92.
[19] Anonymous. Boston Scientific. Available at www. bostonscientific.com/urology.
[20] Karami H, Gholamrezaie HR. Totally tubeless percutaneous nephrolithotomy in selected patients. *J Endourol* 2004;**18**:475–6.
[21] Karami H, Arbab AH, Rezaei A, Mohammadhoseini M, Rezaei I. Percutaneous nephrolithotomy with ultrasonography-guided renal access in the lateral decubitus flank position. *J Endourol* 2009;**23**:33–5.
[22] Häcker A, Wendt-Nordahl G, Honeck P, Michel MS, Alken P, Knoll T. A biological model to teach percutaneous nephrolithotomy technique with ultrasound- and fluoroscopy-guided access. *J Endourol* 2007;**21**:545–50.
[23] Sackett DL, Rosenberg WMC, Muir Gray JA, Haynes RB, Richardson WS. Evidence based medicine – what it is and what it isn't? *BMJ* 1996;**312**:71.