REVIEW

Training in percutaneous nephrolithotomy

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Purpose of review

Training in percutaneous nephrolithotomy (PCNL) necessitates the trainee to climb the steep learning curve of this procedure sequentially. The initial steps of the process should be the acquisition of the necessary skills in a nonintimidating skills lab. We review the current scenario of the training in PCNL and advocate the means that may improve the overall patient care.

Recent findings

The training involves a comprehensive development of the trainee. Initial process starts with the cognitive skills update through conferences and observing peers do the procedure. Rapid prototyping could be useful for resident education. The benefits of three-dimensional stereolithographic biomodeling produced from computed tomography data may aid in achieving optimal access. Skills lab involving wet and dry lab reinforce the cognitive skills. The advantage of live anesthetized porcine model is it being a more realistic model and assessment tool. The specific advantage of the dry lab simulator is of repetitive tasking and easier setup feasibility. There is a lack of guideline for the lab setup and training. Funding, location, number of models installed, curriculum, a trained mentor, and instructor are the critical components that need to be planned in advance.

Summary

Training in PCNL starts with cognitive knowledge, reinforcement through repetitive nonpatient basic skills acquisition in wet and dry skills lab, prototyping the technique before the actual procedure, and finally supervised training under an able mentor.

Keywords

access, PCNL, simulation, skills lab, training

INTRODUCTION

One of the main components of surgical training is the development of operative skills that, in part, is related to the extent of the practical operative experience. Percutaneous endourological procedures require an advanced level of skills. A resident has to perform about 24 percutaneous nephrolithotomy (PCNL) procedures to obtain a good proficiency during the residence period [1]. Stone centers providing all the endoscopic treatment options seem to provide the best conditions to ensure a sufficient volume of patients recruited. For all procedures, significant variability exists between the trainees. There has been a recent decline in the numbers of surgical procedures in urology performed by the trainees [2▪▪]. This calls into question the impact of surgical disasters during the initial long learning curve of the trainees.

The novice surgeon experiences longer median operative and fluoroscopy time, lower stone-free rate, and higher retreatment rate compared to the experienced surgeon [3]. Many grade III complications occur during the first 20 patients of the novice surgeon group [3]. For PCNL, an improvement in the operation duration is observed, and complications decrease significantly after 45 cases [4]. Although it is true that acquisition of skill with live patients cannot be completely replaced by off-patient training in a skills lab, a suitable, realistic, and risk-free skills training can be of great value in the initial steps before contact with a patient for refining techniques and tactics. Key features of any surgical training include the optimal provision of feedback, deliberate practice, training to proficiency, the opportunity to practice at varying levels of difficulty, and the

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KEY POINTS

- A suitable, realistic, and risk-free skills training can be of great value in the initial steps before contact with a patient for refining techniques and tactics.
- Cognitive learning cannot be underestimated as errors during simulated training occur not owing to technical mistakes, but rather from a knowledge gap of the correct sequence of steps in a particular task.
- The most efficient wet lab model is a live anesthetized porcine that closely replicate human kidney model.
- The advantage of simulator is repetitive tasking.
- There remains a lack of guideline for establishing a proper training site facility.

inclusion of both cognitive teaching and hands-on training.

ENHANCING COGNITIVE SKILLS

Before any formal training is imparted, the success depends on the existing element of cognitive learning. The importance of cognitive training is emphasized in several studies. Most errors performed by trainees during simulated training occur not owing to technical mistakes, but rather from a knowledge gap, including a lack of understanding of the correct sequence of steps in a particular task [5]. We all know that percutaneous renal surgery consist of multiple levels of tasking including initial access, dilatation, appropriate tract size selection, nephroscopy, and lithotripsy. However, the most crucial task is the initial access and the success is vastly dependent on it. Any training on PCNL therefore should emphasize on this most crucial step.

The concept is gained when one is constantly reinforced with the procedure during operative workshops, conferences, and day-to-day learning during residency or fellowship. The advantages of cognitive training were demonstrated in a single-blinded, randomized study in which residents allocated to a didactic training group (which included relevant anatomy, steps of a procedure, potential errors, and complications) outperformed a similar group of noncognitively trained residents on a virtual reality simulator [6]. This study emphasizes that cognitive training not only improves an understanding of a particular operation or task, but also improves its execution. It has also been shown that the addition of cognitive training to a technical skills curriculum, even if it reduces the amount of time available to practice a technical skill, does not affect the amount of technical skill learning that occurs [7]. Conferences followed by small group discussions significantly enhance knowledge, attitude, critical appraisal skills, and literature review skills [8]. Recently, there is a widespread acceptance of synchronous online conferences, seminars, meetings, and lectures by the trainees to enhance their knowledge. Web casting based learning also saved time and travel costs. Online conference systems thus offer new opportunities to provide information [9].

PROTOTYPING THE PROCEDURE

Rapid prototyping is a technique used for creating computer images in three dimensions more efficiently than classic techniques. Rapid prototyping could be useful for resident education, allowing the creation of numerous models for research and surgical training. A training model to improve technique and understanding of renal anatomy could improve complications related to renal puncture; however, no model currently exists for resident training [10]. The benefits of three-dimensional stereolithographic biomodeling produced from computed tomography data as an aid to achieving optimal access for percutaneous nephrolithotomy (PCNL) can be unparallel. The biomodeling has the advantage of allowing imaging data to be displayed in a physical form. In difficult cases, this technique may improve treatment, operative planning, and communication with colleagues and patients. The limitations of the technology include the manufacturing time and cost, but more accurate puncture-site selection may reduce costs by saving operating time [11].

ENHANCING SKILLS IN WET LAB

Wet lab encourages the trainee to enhance the basic access skills in a cheap cost-efficient model. There are many ex-vivo animate models described that replicate human kidney model. These models are low cost and simple to set up, with a short preparation time [12–16]. The equipment used in clinical practice can be employed for renal access, tract dilation, nephroscopy, stone disintegration, and stone removal. Imaging is feasible under fluoroscopic and ultrasound guidance. The biological training model simulates realistically the clinical procedure of PCNL under ultrasound and fluoroscopic guidance. Teaching and skill acquisition are practicable. The most common model for training is an ex-vivo perfused porcine kidney, a chicken carcass, and the standard equipment for PCNL [12–15]. For imaging, ultrasound (7.5 MHz) and a fluoroscopy unit are necessary. Artificial stone material is implanted in the renal pelvis. The ureter is cannulated for retrograde pyelography and the renal artery and vein for continuous perfusion. To replicate the presence of the ribs, few authors have put kidneys into bags cut into parts of the thoracic and abdominal wall of these pigs [17]. Especially, puncturing is extremely close to the situation in humans as the porcine thoracic and abdominal wall in principal has the same anatomy as the human one. The new model has been already used with great success in hands-on courses. Concerning 'tissue feeling', the anatomic relations and the great variety of procedures that can be trained, it is superior to nonbiological models. Nevertheless, it is easily available and inexpensive [16].

Though not described as frequently, the in-vivo live anesthetized porcine model is more realistic [18,19]. This may be because of the more resemblance to the real-time situation of anesthesia, a prone animal, a realistic C-Arm unit, real-time retrograde contrast study, movement of the kidney, tactile feedback of the perinephric space and the actual pelvicalyceal system, complications, and aspiration to confirm a successful puncture. An accurate puncture site in the porcine model is difficult in view of difficulty to appreciate the posterior axillary line and a more triangular cross-section of the abdomen [18].

Anonymous evaluations submitted by the training session participants revealed a high degree of satisfaction with model effectiveness in the application of percutaneous renal access (PRA) and nephrolithotomy techniques. Mishra *et al.* [18] compared the PRA obtained on a live porcine model in wet lab and a dry lab computer-based surgical simulator to determine which of the two was a more appropriate and effective training model. He found that training in both the dry and wet lab is effective with relative advantages and disadvantages. The wet lab live porcine model is a more realistic assessment tool for access skills acquisition. The specific advantage of the dry lab simulator is of repetitive tasking and easier setup feasibility. The overall usefulness was the same for both of the models.

ENHANCING SKILLS IN DRY LAB

Currently, three high-fidelity bench models and one virtual reality simulator have been detailed for their utility in learning PRA [1,16]. As there is a large variability in the ability of nondescript inanimate bench models for teaching access skills, the contemporary literature is scanty. Bench models sacrifice fidelity for safety, availability, portability, and reduced cost [20]. Anastakis *et al.* [21] demonstrated that surgical skills learned on bench models were transferred appropriately to human cadavers. The virtual reality simulator is the most utilized model in the dry lab. Perc mentor is a virtual reality simulator specifically developed for training in PRA. It incorporates tactile feedback, organ displacement with breathing, real-time fluoroscopy using virtual C Arm, and mock angiographic instruments. A metal sensor with a spatial sensor is used to achieve percutaneous access into a digitally projected renal collecting system into which contrast medium can be delivered on demand via a retrograde ureteral catheter, with fluoroscopic imaging control with a foot pedal. Real-time feedback confirming successful puncture is available by way of aspiration from the needle. There are several modules of increasing complexity for gaining access skills sequentially.

The advantages of dry lab training are avoiding radiation exposure, repetitive practice, learner friendly environment, complication-free hassles, and no ethical concern [18]. Although the distribution of computer-based simulators is limited by high prices, virtual reality-based training has the potential to become an important tool for clinical education. For five studies reporting comparative costs, simulation was more expensive and more effective [22■■]. In summary, in comparison with other instructions, technology-enhanced simulation is associated with small-to-moderate positive effects. Virtual reality simulators may have a potential in training for PCNL [22■■].

Most of the studies have validated PERC Mentor in training PRA [16,23,24]. The most important and relevant validity is the predictive validity. Although predictive validity implies correlation of virtual reality performance with actual performance of the task, assessment of the trainees in a true clinical setting is neither ethical nor practical. The ideal predictive validity to translate virtual reality skills into clinical percutaneous access proficiency has not been demonstrated. Moreover, inherent variability of the human model precludes standardization of the assessment. Mishra *et al.* [19] reported incorporating different validities in a single study of virtual reality PRA. He used porcine model to replicate live surrogate for the assessment of predictive validity.

CURRICULUM TRAINING

Objective assessment is essential because deficiencies in training and performance are difficult to correct without objective feedback. Although these simulators are now available in many centers throughout the world, little evidence of the effect on clinical skills and the reliability of simulator training have been published. Once the validation benchmarks are proved, this can be incorporated in the teaching curricula. Although skills training have been well validated as tools to teach technical skills, their integration into comprehensive curricula is lacking. Moreover, neither the effect of ex-vivo training on learning curves in the operating room nor the effect on nontechnical proficiency has been investigated. A randomized, single-blinded, prospective trial allocated 20 surgical trainees to a structured training and assessment curriculum (STAC) group or conventional residency training. The STAC consisted of case-based learning, proficiency-based virtual reality training, laparoscopic box training, and operating room participation. Residents in the STAC group outperformed residents in the conventional group. STAC-trained residents had superior technical proficiency in the operating room and nontechnical skills compared with conventionally trained residents [25]. Vicarious learning lead to greater knowledge of doctor–patient communication scores than learning by doing [26]. Students appear to learn at least as much, if not more, about doctor–patient communication by observing their peers interact with patients. Instructional support for observing simulations in the form of observation scripts facilitates both vicarious learning and learning by doing.

TRAINING SITE FACILITY

Developing a PCNL training program through skills lab necessarily involves doing a feasibility analysis to determine whether or not the program is needed and whether the necessary resources are available to implement and support it over the long term. Providing a simulator-training program requires both initial and continuing sponsorship. In considering funding, it is important to have at least a ballpark view of what it costs to provide such a program. The selection of the simulators and other support equipment greatly affect the quality of the training program. The dry lab facility involving setting up of virtual reality simulator for percutaneous access requires huge capital cost. However, the down side of start-up costs is taken care by the low costs of maintenance. If the wet lab is designed, then it is mandatory to answer where and how is it housed? The inanimate and the live anesthetized model have certain requirements that must be met. Most common is to house them in a fixed location and bring the students to that site. A fixed location should be centrally located and easily accessible. Anticipating the needs of the program for at least 5 years is necessary to justify the investment required in the developing training site. It is also important to visit existing training sites to view the operations and talk with experienced trainers. The day-to-day operations of the training program require a management structure that ensures effectiveness. This includes the responsibility for overall coordination, supervision of administrative personnel and instructors, and the administrative functions of student record keeping, accounting, and the preparation of management reports. As these programs are relatively new, there is limited information available on how training programs are appropriate in any specific area. If there are too many in a region, there may be excessive competition for trainees, underutilization of expensive equipment, and underutilization of instructors, who then lose interest in the program.

Finally, the number of students to be trained at one time and the instructor-to-student ratio are key factors in determining the number of models to purchase. The type of equipment selected may limit the number of students who may be trained at the same time. These factors affect the efficiency of the training operation. The instructor is the bridge between the student and the simulator. The instructor must possess the ability to patiently guide the student through the orientation and training process. An effective instructor is the key to making the simulator a meaningful training experience.

CONCLUSION

The status of modern day minimally invasive surgery including performing PCNL has undergone a sea change. This era belongs to the concept of learning, unlearning, and relearning. Simulation has a vital role to play in the access of skills required for PCNL. A suitable, realistic, and risk-free skills training can be of great value in the initial steps before contact with a patient for refining techniques and tactics. Cognitive learning cannot be underestimated as errors during simulated training occur not owing to technical mistakes, but rather from a knowledge gap of the correct sequence of steps in a particular task. The most efficient wet lab model is a live anesthetized porcine that closely replicates the human kidney model. The advantage of simulator is repetitive tasking. There remains a lack of guidelines for establishing a proper training site facility.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

▪ of special interest

▪▪ of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 185–186).

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