Achieving Procedural Competence during Nephrology Fellowship Training: Current Requirements and Educational Research

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Abstract

Concerns have previously been raised as to whether training programs are ensuring that nephrology fellows achieve competence in the procedural skills required for independent practice. We sought to review the current requirements for procedural training as well as educational research pertaining to achieving competence in the core nephrology procedures of nontunneled (temporary) hemodialysis catheter insertion and percutaneous kidney biopsy. At this time, there is no universal approach to procedural training and assessment during nephrology fellowship. Nonetheless, simulation–based mastery learning programs have been shown to be effective in improving fellows’ skills in nontunneled (temporary) hemodialysis catheter insertion and should be provided by all nephrology training programs. For percutaneous kidney biopsy, the development and evaluation of inexpensive simulators are a promising starting point for future study. Current practice with respect to procedural training during nephrology fellowship remains imperfect; however, the ongoing shift toward competency-based evaluation provides opportunities to refocus on improvement.


Introduction

In 2008, Kohan (1) argued in the Clinical Journal of the American Society of Nephrology that, as a specialty, nephrologists were “at risk [of] failing to steer our own course in training fellows in procedural nephrology” (1). Kohan (1) advocated that evidence–based procedural guidelines be established to ensure that fellows would be adequately trained to provide patients with high-quality care. This came in response to a survey of United States adult nephrology training programs that reported that over one half of programs had no minimum requirements for most procedures that were being taught (2). It is unclear the extent to which procedural training during nephrology fellowship has changed since that time; however, the ongoing shift toward competency-based training (3–5) and away from active learning.

In this brief review, we seek to highlight educational aspects of procedural training for nephrology fellows. We will review current requirements for procedural training as well as research that has been conducted into establishing competence for the core nephrology procedures of NTHC insertion and PKB. In doing so, we also aim to present tools and resources that are available to practitioners and educators that may assist in designing procedural training that is conducive to active learning.

Procedural Requirements for Nephrology Trainees

The American Board of Internal Medicine (ABIM) and the Accreditation Council for Graduate Medical Education (ACGME) stipulate procedural training requirements for trainees and programs (Table 1). Neither the ABIM nor the ACGME stipulate how these requirements for procedural competence should be taught or evaluated.

Consistent with the ABIM and the ACGME, the American Society of Nephrology (ASN) Training Program Directors implementation draft for Nephrology Curricular Milestones (14) stipulates that readiness for practice requires the ability to independently...
insert NTHCs and perform PKB of both native and transplanted kidneys. In the 2008 survey of United States nephrology programs by Berns and O’Neil (2), nearly all programs reported that they were providing training in NTHC insertion and PKB. It should be noted that only approximately 50% of programs reported that training for PKB included ultrasound training to allow performance of the procedure without a radiologist (2).

Although the ability to insert NTHCs remains a requirement of training internationally (15–17), some jurisdictions (including Canada [17] and the United Kingdom [16]) no longer require nephrology fellows to perform PKB beyond providing counseling about the risks and benefits. The licensing authority for Australia and New Zealand (The Royal Australasian College of Physicians [RACP]) suggests that fellows complete 20–50 native and/or transplanted kidney PKBs during their training (15); however, the basis for this recommendation is unclear.

Although not directly applicable to the requirements of standard nephrology fellowship training, for NTHC insertion, the American Society of Diagnostic and Interventional Nephrology states that, for interventional nephrology certification, 25 catheters should be placed to achieve competence (18). This number of procedures may be on the basis of studies showing that inexperienced operators had higher complication rates than experienced ones (7,19). Such studies were conducted before routine use of real-time ultrasound guidance (now the standard of care for NTHC insertion [20]), and the use of ultrasound may mitigate the risk of complications by less experienced operators (7,21–23). One study showed that, for intensive care unit residents inserting central venous catheters (CVCs), the success rate increased to 90% after 10 ultrasound–guided catheter insertions and that the rate of complications declined to (and persisted at) approximately 8% after having placed only four catheters (24). The RACP indicates that it is highly desirable that nephrology fellows place 10–20 vascular catheters under clinical supervision (15); however, the basis for this recommendation is not reported.

Training for Nephrology Procedures
Temporary Hemodialysis Catheter Insertion

Given its similarity to insertion of other types of nontunneled CVCs, the best studied nephrology procedure is that of NTHC insertion. Multiple studies have assessed the use of simulation–based mastery learning (SBML) training for nontunneled CVC insertion (25–31), including those that have more specifically assessed nephrology trainees inserting NTHCs (25,26,31). Unfortunately, NTHC insertion training for nephrology fellows is also similar to CVC insertion training for critical care trainees in that there is “no standardized definition of competency or universal approach to simulation-based training” (32).

SBML is a form of competency-based education that involves participants learning a procedure through the use of realistic simulators and clinical scenarios (33,34). Before any formal teaching, learners undergo pretesting in which their performance of the entire procedure using simulation is graded using a checklist. Learners are then given directed feedback about their pretest performance and didactic teaching about the correct technique for performing the procedure from start to finish. This is followed by a period of deliberate skills practice and feedback using the simulator. Trainees are then evaluated using a post-test, in which they are re-evaluated using the same checklist. Learners continue to participate in deliberate practice with feedback and repeated post-testing until such time as they meet or exceed a predetermined minimum passing score (MPS). By setting a stringent standard for the MPS, training time may vary across learners, but all must achieve a high level of performance by the end of training.

The use of SBML to teach nontunneled CVC insertion in the intensive care unit setting is one of the few educational interventions shown to improve patient outcomes: Barsuk and colleagues (27,29,30) showed that the use of SBML improved medical residents’ skills in performing nontunneled CVC insertion (29) and reduced both mechanical complications (30) and central line–associated bloodstream infections (27). The reduction in bloodstream infections was associated

### Table 1. Procedural training requirements for fellows and training programs in the United States

<table>
<thead>
<tr>
<th>Procedure</th>
<th>ACGME Requirements</th>
<th>ABIM Requirements</th>
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<tbody>
<tr>
<td>NTHC insertion</td>
<td>Trainees must show competence in insertion of NTHCs; trainees must show knowledge of the principles of acute dialysis access with respect to techniques, indications, and potential complications</td>
<td>Trainees must be competent to insert NTHCs</td>
</tr>
<tr>
<td>PKB</td>
<td>Trainees must show competence in performing PKBs of both native and transplant kidneys</td>
<td>Trainees must be competent to perform PKBs of both native and transplant kidneys</td>
</tr>
<tr>
<td>General requirements</td>
<td>Trainees are expected to develop skills and habits to obtain procedure–specific informed consent by competently educating patients about the rationale, technique, and complications of procedures</td>
<td>NA</td>
</tr>
</tbody>
</table>

ACGME, Accreditation Council for Graduate Medical Education; ABIM, American Board of Internal Medicine; NTHC, nontunneled (temporary) hemodialysis catheter; PKB, percutaneous kidney biopsy; NA, not applicable.
with significant cost savings, showing a 7:1 rate of return on the cost of the SBML intervention (35). Studies that have assessed SBML for teaching nephrology trainees to insert NTHCs have shown it to be effective at improving their performance of the procedure on a simulator shortly after completing training (25,26,31), but this has not been followed out to clinical outcomes.

There are limited data on retention of skills after SBML training. One study assessed skill retention among nephrology fellows after SBML training for NTHC but was limited by small numbers of trainees assessed (25). Three of 12 fellows in this study underwent retesting (using real patients) 6 months after their SBML training, and it was discovered that they had no significant decay in their skills (25). Eleven of these 12 fellows also underwent testing using a simulator at 1 year after their initial training; scores were noted to be significantly lower at that time (25). As such, the authors suggested that "booster training" be considered at 6-month intervals (25). Given the implication that repeated training sessions might be required and the attendant time and cost commitments (potentially at the expense of other fellowship learning objectives [11]), more study is needed to assess the persistence of competence after SBML training, particularly in the real world setting and related to the number of procedures that fellows perform on an ongoing basis after their initial training.

An additional factor supporting the use of SBML training is the quality of instruction available in the clinical setting. There is evidence to suggest that many of the attending nephrologists responsible for supervising and teaching NTHC insertion may not be skilled in performing the procedure themselves. A recent single-center study by McQuillan et al. (36) showed NTHC insertion skills of attending nephrologists were highly variable and did not differ significantly from those of their nephrology fellowship trainees (when assessed using simulators with the checklist developed and validated by Barsuk et al. [26]): very few trainees or attending staff were proficient at NTHC insertion before SBML training (36).

For nephrology programs wishing to provide SBML training for NTHC insertion, the original paper by Barsuk et al. (26) and a subsequent paper describing SBML training at a continuing medical education meeting (31) provide detailed methods. Notably, all studies of nephrology trainees, to date, have used the checklist and MPS of 79% established for the original study of 18 nephrology fellows from three academic centers in Chicago conducted by Barsuk et al. (26). The MPS in that study was established by a multidisciplinary panel according to a rigorous item—and group—based standard setting method (26). A modification of the initial checklist has been included in the ASN Training Program Directors Toolkit (37) as a possible evaluation tool (but outside the context of SBML training [6]). In 2014, Ma et al. (38) reported a comprehensive systematic review of assessment tools used for measuring competence in CVC insertion. For those considering modifying a pre-existing checklist for trainee assessment, this study is a valuable resource that includes a complete list of the assessment items used across multiple studies (38). When considering the real world applicability of assessment tools for CVC insertion, it is relevant to note that most tools under-represented "team-working" and "communication with the patient" (38), which are important aspects of competence for this procedure and others.

PKB

Despite its crucial role in establishing nephrology as its own specialty (39), PKB is now frequently performed by non-nephrologists (10,40–43). This is likely because of multiple factors, including nephrologists’ economic and liability concerns (44). One consideration is that, as real time ultrasound—or other imaging, such as computed tomographic or fluoroscopic imaging—guidance has become the standard of care for PKB, some nephrologists may have decided that they had inadequate skills to use these imaging techniques and deferred to their radiology colleagues (45). Unlike for NTHC insertions, where real time ultrasound guidance is a required skill for the operator, the performance of the PKB may be effectively performed in many institutions by nephrologists and trainees in collaboration with an ultrasonographer. Nonetheless, it is unclear what effect the overall reduction in nephrologists’ involvement in performing PKBs may be having on training opportunities for nephrology fellows, because little research has been done with respect to teaching of PKB. In addition, to our knowledge, no assessment tools have specifically been evaluated.

Practicing nephrologists have been shown to perform PKB with a similar complication rate to that of radiologists (43,45) and are more inclined to use techniques (such as using larger-gauge needles/biopsy guns) that improve diagnostic yield (40,43,45). As highlighted in an editorial by Whittier and Korbet (46), radiologists tend to favor using 18-gauge needles for PKB because of a perception that larger-gauge needles are associated with more complications (47); however, multiple prospective studies of automated needle PKBs have not shown this to be the case (10,40,43,48–50). Given that obtaining more glomeruli per core is associated with greater diagnostic accuracy (51), “[a]s long as radiologists continue to favour the smaller needles, the biopsy is more suited to be in a nephrologist’s hands” (46).

Traditionally, PKB training has been obtained through formal teaching and clinical exposure (52). Given that training in this manner necessitates inexperienced operators performing PKBs, complications may occur at a higher rate in hospitals with training programs (53–55). This suggests that the use of simulation training could be highly desirable for teaching and assessing PKB, particularly given the potential for fatal complications (50,56).

In 2010, Mrug and Bissler (52) reported a detailed method to create a realistic and inexpensive simulator for real time ultrasound-guided PKB using a porcine kidney and turkey breast (available from a butcher or grocery store). A similar simulator, also using a porcine kidney but with the possible benefit of fewer air inclusions for more realistic ultrasound imaging at a slightly higher cost, has been described by Woywodt et al. (57). Using their simulator, Mrug and coworkers (58) subsequently showed that, for a group of 10 nephrology fellows, procedural confidence levels increased significantly after simulation training. In addition, compared with eight fellows who did not receive simulation training, the simulation-trained group showed relatively better competence in performing the procedure on patients as evidenced by more successful retrieval of tissue
per needle pass (94% versus 73%; P=0.002) and less procedure–related blood loss with a smaller postbiopsy decline in hematocrit (1.18 versus 2.68; P=0.05) (58). Although far from definitive support for the efficacy of simulation-based training for PKB, these studies represent a starting point for determining how to best provide PKB training for nephrology fellows. Future studies are needed to evaluate and objectively measure outcomes of well defined simulation–based training programs for PKB. Future work in this field will be necessary if the PKB is to remain within the scope of nephrology practice, something that many argue is beneficial for both patient care and the future of our specialty (1,7,10,59).

With respect to training resources for PKB, the ASN Training Program Directors Toolkit (37) provides a comprehensive template (the Montefiore Nephrology Fellowship Evaluation) for evaluation of fellows’ performance of renal biopsies but does not focus on procedural technique. An excellent teaching resource for the theoretic aspects of PKB training (native and transplanted kidneys) is the Australian and New Zealand Special Interest Group for Interventional Nephrology Kidney Biopsy Learning Program (available without charge at http://renalbiopsy.com.au). Those who do not have an Australian Health Practitioner Registration number may use any local professional registration number to obtain free and unrestricted access online. Another state of the art resource pertaining to the theoretic aspects of native kidney biopsy is the recently published mini–review by Hogan et al. (60).

Conclusions
At this time, there is no standard approach to procedural training during nephrology fellowship. In addition, no universally accepted approach to the evaluation of procedural competencies has been developed. SBML training for NTHC insertion has been relatively well studied and should become a mandatory requirement of nephrology fellowship training. However, given that repeated SBML sessions might be required to maintain competence, perhaps at the expense of other educational objectives, more study is needed to assess the extent to which competence persists after initial SBML training in the real world setting and is related to the number of procedures that are performed on an ongoing basis during training. As highlighted by the study by McQuillan et al. (36), SBML training to ensure that the attending nephrologist supervisors are themselves competent in NTHC insertion may, in many cases, be a necessary initial starting point for improving training (61).

For the other core nephrology procedure of PKB, there is a paucity of data to guide training and evaluation. The development of simulation training programs for PKB is a promising advance, and additional evaluation of such programs should be encouraged.

At this time, in accordance with the ABIM and to maintain certification, United States nephrology training programs and program directors have a professional requirement to ensure that their trainees are competent to perform NTHC and PKB without direct supervision. For some programs, providing a dedicated rotation in interventional nephrology may be one way to increase trainees’ exposure to procedural skills training. In this way, trainees may get enhanced exposure to PKB and NTHC insertion but also, may participate in and develop an interest in pursuing additional training in tunneled catheter insertion, fistulograms, venograms, peritoneal dialysis catheter insertions, and even percutaneous nephrostomies.

Unfortunately, despite the call for change by Kohan (1) in 2008, we still seem to be far from determining how to best provide procedural training during nephrology fellowship. Although current practice with respect to procedural training remains imperfect, the overall shift toward competency-based evaluation provides opportunities to develop and validate procedural training techniques and assessment tools. There is sufficient evidence to recommend that all training programs ensure their fellows receive SBML training for NTHC insertion. The evaluation of SBML training programs for PKB is a focus of future study. Renewed efforts to establish objective and valid measures of procedural competence will be necessary if the core nephrology procedures of NTHC insertion and PKB are to remain within the scope of general nephrology practice.

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Disclosures
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References


34. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB: Medical education featuring mastery learning with deliberate practice can lead to better health for individuals and populations. *Acad Med* 86: e8–e9, 2011


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