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Standardization of Health Care Provider Competencies for Intrathecal Access Procedures CE

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Abstract

Introduction: This quality improvement (QI) project addresses a method for experienced health care providers to maintain skill-based competence for intrathecal access procedures. **Methods:** A prospective QI design using intrathecal access simulation to assess, educate, and evaluate skill competency. Simulation was used as a strategy to promote patient safety and standardize practice patterns. Pretest and posttest methodology using paired *t* tests were performed to assess anxiety, confidence, and knowledge. **Results:** Fourteen pediatric providers participated in this QI project. There was a statistically significant improvement in confidence measuring intracranial pressure (ICP; $t = -2.92$, $P = .013$), performance-related overall anxiety ($t = -2.132$, $P = .05$) and administering intrathecal chemotherapy ($t = -2.144$, $P = .053$). Fifty percent of participants missed a medication error demonstrating confirmation bias. **Conclusion:** This simulation strategy resulted in improved confidence in measuring ICP, performance-related overall anxiety, and confidence in administering chemotherapy. Confirmation bias occurred during simulation testing for a medication error. We propose this method for maintaining clinical competencies in health care providers and introducing new skills to existing practices.

Keywords

diagnostic lumbar puncture, therapeutic lumbar puncture, intrathecal chemotherapy, skill decay, confirmation bias

Introduction

Health care providers, including nurse practitioners (NPs), physician assistants (PAs), and physicians (MDs) demonstrate competence in a required practice skill during their initial training. These professionals are expected to retain their competency and skill throughout the regular practice of these skills. Experienced health care providers who perform a skill on a routine basis may develop variations in their practice patterns as confidence in the skill develops, especially if no adverse event occurs. Additionally, when extended periods of time lapse between skill practice and retraining, skill decay may occur. Skill decay is the loss of an acquired skill or knowledge after periods of nonuse (Arthur, Bennett, Stanush, & McNelly, 1998).

Procedures that involve intrathecal (IT) access require complex technical skills that are at high risk for skill decay. Examples of these IT procedures are diagnostic lumbar punctures (LPs) for measuring intracranial pressure and obtaining cerebrospinal fluid (CSF) and therapeutic LPs for the administration of chemotherapy, analgesics, or antispasmodics. The use of the IT route to administer complex and experimental treatments is expanding. For example, Orchard et al. (2007) suggested that the delivery of stem cells by IT or intraventricular injection may provide an alternative to the limited penetration across the blood-brain barrier for inherited metabolic conditions, such as lysosomal enzyme deficiencies. The need for practitioners who are competent and confident in this skill is likely to increase. Yet the opportunity to practice this skill on a regular basis is limited. This

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makes this high-risk skill an ideal fit for a structured practice skill competency protocol.

In addition to the prevention of skill decay, standardization of skill competency ensures that all providers within an institution follow the same, evidence-based, standard operating procedures (SOPs) for a particular skill. The development of an SOP for a skill provides a method for establishing competency as well as a standardized approach that reduces practice variation in a clinical setting. One strategy to improve skill competency for IT access procedures by experienced health care providers is through the use of simulation. Simulation provides a safe environment for health care providers to learn, practice, and maintain a complex, high-risk competency skill.

Simulation is defined as the recreation of an act or event by another (Society for Simulation in Healthcare, 2013). Simulation began in the aviation industry in the 1930s with use of the first flight simulator, but it was not until the 1980s that simulation in health care was adopted. Anesthesiologists first used simulation as a method to identify and manage critically ill patients in the operating room (Cates & Wilson, 2011). Since that time, simulation in health care has evolved as a primary tool for education and competency-based assessment (Cates & Wilson, 2011; Jeffries, 2005; Lenchus, 2010). Recent reports support the use of patient simulators to maintain competencies for experienced health care providers (Cates & Wilson, 2011; Pascual et al., 2011). The Society for Simulation in Healthcare (2013) identifies the broad purpose of simulation to "improve the safety, effectiveness, and efficiency of healthcare."

Background and Significance

Health care providers often learn critical skills needed for their specific roles through an apprenticeship model. This is commonly referred to as a "see one, do one, teach one" methodology (Lenchus, 2010). The apprenticeship model becomes problematic when the teacher performs a procedure in a manner inconsistent with evidence and institutional SOPs. This often results in errors or complications impacting patient safety (Lenchus, 2010). In addition, the demonstration of skill competency varies across different organizations and specialty services. Most health care professionals maintain their competency through regular practice of these skills. However, experience in a procedural skill performed on a frequent basis, especially without any patient sequelae may lead the provider to develop shortcuts or variations in clinical practice patterns leading to concerns in patient safety. These providers may serve as an apprentice or preceptor for newly hired health care providers perpetuating the variability in practice.

In a meta-analysis of 53 articles on skill decay (Arthur et al., 1998) aggregated effect sizes related to nonpractice or nonuse were computed to show an overall magnitude of skill loss. Results supported that substantial skill loss, due to nonpractice or nonuse, occurred after more than 365 days compared with minimal skill loss immediately after training defined as less than 1 day (Arthur et al., 1998). This meta-analysis showed that skill decay may become problematic when 1 year or greater has lapsed since the performance of the procedure.

Medication errors involving the IT space have a high potential for grave consequences to the patient. For example, an injection of the chemotherapeutic agent vincristine given accidently through the IT route instead of its indicated intravenous route, can cause fatal neurologic effects (Smith, 2009). The National Patient Safety Agency (2001) and the Joint Commission (2005) have both issued an alert about the fatal effects of such an error in the administration of vincristine. As many as 55 incidents of incorrect vincristine administration have been documented worldwide since 1968 (Smith, 2009), highlighting patient safety as a concern for administration of IT medications.

The purpose of this quality improvement (QI) project was to design and evaluate a process for maintaining competency and standardized practice for IT access procedures by experienced health care providers through the use of simulation. The aims of the project were to (*a*) design a simulation module to assess provider competency in IT access procedures and develop standard operating procedure of that skill set across providers and (*b*) implement the simulation module using simulation as a strategy to promote patient safety. This study can serve as a prototype for the design and implementation of QI training for clinical competencies across health care professionals and disciplines.

Literature Review and Synthesis of the Evidence

A comprehensive review of the literature was conducted in 2 focal areas. The initial review focused on literature describing the LP procedure and skill set. The second review examined published evidence on the use of simulation as a teaching mode and its impact on provider clinical competence, confidence, and knowledge. In addition, references cited from the articles reviewed also contributed to this review. The search was initiated by using Medline through PubMed, and CINAHL (Cumulative Index to Nursing and Allied Health Literature) with the MeSH (Medical Subject Headings) and CINAHL subheadings: clinical competence, competency-based education, evidence-based practice, manikins, mannequin,

Table 1. Evidence-Based Practice Recommendations for Minimizing Complications of Diagnostic Lumbar Punctures.[a]

Reference	Reference Type	CT Scan Not Required	Bed-rest Not Required	Replace Stylet Before Withdrawing Needle	Insert Bevel of Needle Perpendicular to Longitudinal Fibers	Epidural Patch Application for CSF Leak	Mask Worn by Provider	Needle-Type (Conventional vs Atraumatic) Recommendations
Flaatten, Felthaus, Kuwelker, and Wisborg (2000)	RCT							✓
Janssens, Aerssens, Alliet, Gillis, and Raes (2003)	Systematic review				✓	✓		
Lee, Sennett, and Erickson (2007)	Systematic review		✓		✓			
Schneeberger, Janssen, and Voss (1996)	Review						✓	
Straus, Thorpe, and Holroyd-Leduc (2006)	Systematic review		✓	✓		✓		✓
Williams, Lye, and Umapathi (2008)	Systematic review	✓	✓	✓			✓	✓

Abbreviations: RCT, randomized control trial; CT, computed tomography; CSF, cerebrospinal fluid.
[a]Each check mark (✓) denotes the evidence-based practice recommendations cited in the literature. These recommendations were used to build the standard operating procedure.

patient simulation, intraspinal, intrathecal, practice guidelines, nursing and nurses role, lumbar puncture, lumbar puncture adverse effects, lumbar puncture children, spinal puncture, skill decay, and confirmation bias. Limits for the literature search were English and humans.

Literature Review of the Lumbar Puncture Procedure

A review of the literature documenting complications related to LP procedures was conducted. Table 1 depicts evidence-based recommendations based on 6 studies minimizing complications related to the diagnostic LP procedure. Four of the 6 studies were systematic reviews which provided the strongest evidence for making a practice change.

The 4 systematic reviews described consistent recommendations to minimize complications associated with diagnostic LPs. Evidence-based recommendations include (*a*) Neither is computed tomography (CT) scan of the brain required prior to the LP procedure (Williams, Lye, & Umapathi, 2008) nor is it necessary to increase fluids or ensure bed rest following the LP (Lee, Sennett, & Erickson, 2007; Straus, Thorpe, & Holroyd-Leduc, 2006; Williams et al., 2008); (*b*) atraumatic needles for diagnostic LPs (Flaatten, Felthaus, Kuwelker, & Wisborg, 2000; Straus et al., 2006; Williams et al., 2008); (*c*) if conventional needles are used, the stylet should be replaced before withdrawing the needle (Straus et al., 2006; Williams et al., 2008); (*d*) the needle bevel be inserted perpendicular to the longitudinal dural fibers (Janssens, Aerssens, Alliet, Gillis, & Raes, 2003; Lee et al., 2007); (*e*) adult patient needle gauge range between 20-G and 22-G, smallest gauge available to minimize the CSF volume to be removed (Lee et al., 2007); (*f*) surgical masks should be worn during a diagnostic LP, especially if the procedure is expected to be prolonged or if the operator has an upper respiratory infection (Williams et al., 2008); (*g*) aspiration of CSF through the needle during the LP should never be done since a small amount of negative pressure can cause subdural hemorrhage or herniation (Boon, Abrahams, Meiring, & Welch, 2004).

Literature Review on Use of Simulation

Five overlapping outcome categories were identified in the literature on simulation. Commonly reported outcome categories were confidence and knowledge, while less commonly reported categories were related to anxiety. Recently reported categories were related to error reduction and translation of competency skills into clinical practice. Several studies consistently demonstrated overall improvement in self-confidence using simulation (Bambini, Washburn, & Perkins, 2009; Blum, Borglund, & Parcells, 2010). The use of simulation as an alternate instructional method was shown to enhance knowledge and cognitive skills for nursing students and NP students when compared with traditional classroom lecture (Brannan, White, & Bezanson, 2008). In a pilot, prospective cohort study, Corbridge et al. (2008) found significant differences in knowledge and confidence ($P = .019$); this confidence significantly improved management of a mechanically ventilated patient ($P = .031$) and a patient with septic shock ($P = .007$).

A less common outcome variable was health care provider anxiety. Allan et al. (2010) used simulation to implement a simulation-based crisis resource management curriculum using pediatric cardiac intensive care unit scenarios. Participation in cardiac/respiratory arrests following the curriculum led to differences in nurses' anxiety levels, but not in physician anxiety levels ($P < .001$).

A growing body of evidence supports the use of simulation for error reduction and translation from the simulation laboratory into clinical practice. A prospective, multicenter, empirical study by Morey et al. (2002) was done to evaluate the Emergency Team Coordination Course. Trained observers rated emergency department (ED) staff on team behaviors and made observations on clinical error as a measure of ED performance using a dichotomous measure. The observers noted that the clinical error rate significantly decreased from 30.9% to 4.4% in the experimental group ($P = .039$). However, the translation and maintenance of skills from a traditional education program to the clinical area has proven difficult to establish. Inconsistent findings include a randomized control trial (RCT) of 38 pediatric residents who received a modular curriculum on LP procedures found no difference in overall success (77% vs 62%, $P = .38$) or final assessment (69% vs 69%, $P = .80$) between the intervention group that received instruction using simulation versus the control group that received the standard curriculum alone (Gaies et al., 2009). However, a similar RCT by Kessler, Auerbach, Pusic, Tunik, and Foltin (2011) of 56 residents measuring experience, knowledge, and confidence, demonstrated that the intervention group who performed a live infant LP following simulation, obtained CSF in 94% of the cases compared with only 47% of the control group who received audiovisual training alone (absolute risk reduction = 47%, 95% confidence interval = 16% to 70%; $P = .005$). No differences were found between the groups at 6 months on performance, knowledge, or confidence. Simulation has been shown to be a strategy for the maintenance of skills when opportunities for actual practice of the skill are lacking. Kaczorowski et al. (1998) found an overall decline in the mean neonatal resuscitation provider life-supporting performance scores (from 92% to 66%), $F(1, 41) = 308.1$, $P < .001$. In follow-up testing, those residents in the hands-on group made significantly fewer errors at follow-up than the combined control and video groups averaged across 5 scenarios (72% vs 63%), $F(1, 41) = 5.7$, $P = .21$. Thus, the reinforcement of skills through the use of simulation was found to be a powerful strategy to improve performance in the absence of real-time clinical experience.

Published literature consistently supports simulation as an effective method to increase the participant's confidence and knowledge while decreasing anxiety and error rate. The results of 1 RCT supported the translation of skills learned in simulation to competencies in clinical practice (Kessler et al., 2011) and 2 RCTs supported that simulation can reinforce skills learned previously (Kaczorowski et al., 1998; Sudikoff, Overly, & Shapiro, 2009). Thus the literature provided supported designing a simulation exercise for a group of health care professionals performing LPs as part of their standard practice caring for pediatric patients with life-threatening disease.

Methods

Study Design

This QI project used a prospective QI design with simulation as a method to evaluate health care provider competencies and critical thinking during and after the skill demonstration. The purpose of this project was to design, implement, and evaluate a procedure for skill-based competency assessment of IT access procedures across health care providers. The overall goal was to develop a procedure for the maintenance of health care provider competencies in IT procedures using simulation as a strategy to promote patient safety and reduce variations in practice patterns.

Organizational Setting

This project was reviewed by the institutional review board and received exempt status, which did not require participant consent. The project was implemented in a large tertiary care academic health care system serving both pediatric and adult patients. The children's hospital, is is part of the matrix organization of the health system, provides primary and specialty care to the pediatric population. For the year 2011, it was estimated that 31 diagnostic LPs were performed by the pediatric blood and marrow transplantation (PBMT) service at this children's hospital (R. Vinesett, personal communication, March 7,

Table 2. Participant Characteristics.

Provider Characteristics	n (%)
Provider type	
Nurse practitioner	9 (64.3)
Physician	5 (35.7)
Number of years of experience in current health care provider role	
<5	5 (35.7)
5-10	3 (21.4)
11-15	1 (7.1)
16-20	2 (14.3)
>20	3 (21.4)
Number of years performing diagnostic lumbar punctures (LPs)	
<5	5 (35.7)
5-10	5 (35.7)
11-15	2 (14.3)
16-20	0 (0)
>20	2 (14.3)
Number of years performing therapeutic LPs	
<5	7 (50.0)
5-10	3 (21.4)
11-15	2 (14.3)
16-20	0 (0.0)
>20	2 (14.3)
Number of diagnostic LPs performed in the past year	
0	3 (21.4)
1-3	3 (21.4)
4-6	3 (21.4)
7-10	2 (14.3)
>10	3 (21.4)
Number of therapeutic LPs performed in the past year	
0	4 (28.6)
1-3	2 (14.3)
4-6	2 (14.3)
7-10	1 (7.1)
>10	5 (35.7)

2013). The administration of IT chemotherapy on the PBMT service occurred less frequently with only 3 therapeutic administrations of IT chemotherapy during the year 2011. If a child on the PBMT service required IT chemotherapy, then 1 of the 17 credentialed health care providers on the PBMT service would be required to perform this procedure.

Sample

A convenience sample of 14 out of 30 health care providers was recruited across the PBMT service, the Pediatric Hematology-Oncology service, and the Pediatric Neurology service. These health care providers were targeted because the performance of diagnostic and/or therapeutic LPs is a skill set required in practice. As shown in Table 2, the sample was composed mostly of NPs (64%) and physicians (36%). Clinical experience of the health care providers ranged from novice to expert. More than half of the participants (57%) had 10 years or less experience in their current health care provider role. Seventy-one percent of the health care providers had been performing diagnostic or therapeutic LPs for 10 years or less. Twenty-one percent of the health care providers had not performed any diagnostic LPs within the past year. Twenty-seven percent had not performed a therapeutic LP within the past year.

Development of the Simulation Module

A collaborative team of experienced health care providers served as an expert panel for the development of this QI simulation module. The expert panel included (*a*) the division chief of the PBMT service, (*b*) an attending physician on the pediatric hematology-oncology service, (*c*) an acute care pediatric NP and clinical instructor at a school of nursing, (*d*) the DNP investigator, a pediatric NP with the PBMT service. Three planning meetings were held to design the simulation exercises and create an evidence-based SOP for IT skills. The development of the SOP included the empirical evidence gathered from published literature. A summary of the practice guidelines is found in Table 3. A dichotomous psychomotor skills checklist was agreed upon by consensus of the collaborative team. The expert panel agreed on an education intervention that would be used during the simulation and logistical flow through the simulation stations was determined. Providers were offered 3 dates to participate in the simulations.

Measures

The measures used for the simulation included the following: (*a*) demographic form that described the health care provider, years of experience in current role, and experience with recent and overall diagnostic and therapeutic LPs; (*b*) 2 dichotomous psychomotor skills checklist, one used for prereview and one for postreview of the education intervention; (*c*) a 3-item, 5-point Likert-type scale of pre- and postsimulation confidence; (*d*) a 2-item, 5-point Likert-type scale of pre- and postsimulation anxiety (this measure included an open-ended question asking the participant for the step in the procedure causing the most anxiety); and (*e*) a postsimulation evaluation survey to assess usefulness of the simulation procedure. Standardized measures for anxiety were considered, but found to be lengthy and nonspecific for the diagnostic and therapeutic LP procedure competency. We found confidence measures in the literature specific to the LP procedure and modified them as well as developed the anxiety measure to be specific for our simulation exercise. The measures were printed on different colored paper for ease of instruction for participants and expert evaluators as well as to prevent confusion with the identical pre- and postpsychomotor skills checklists.

Procedures

The simulation exercises lasted 30 minutes each with participants sequentially rotating through 3 simulation stations. Two of the simulation stations were designed to test pre- and postknowledge using a psychomotor skills checklist. Pediatric and adolescent simulators were used at the first and third simulation stations to provide the participants experience with the different age competency requirements. At the second station the participants received the education intervention.

Implementation of the Simulation Module

On entering the simulation laboratory, the participants received a manila envelope containing the demographic measure, 2 psychomotor skills checklists, pre- and post-simulation anxiety and confidence scales. Each participant was assigned an anonymous code number that would link each of the data collection measures. The participants proceeded to the first psychomotor station to demonstrate their baseline evaluation of diagnostic and therapeutic LP skills using a pediatric infant simulator with an articulating spine that provided a flashback of simulated CSF. Participant skill performance was evaluated at this station by a member of the expert panel using the prereview psychomotor skills checklist. The participants then proceeded to the second station (education intervention), where they (*a*) viewed an 11-minute *New England Journal of Medicine* evidence-based video on the safe and successful method for performing an LP (Ellenby, Tegtmeyer, Lai, & Braner, 2006), (*b*) reviewed the pediatric outpatient pharmacy policy for the dispensing of IT chemotherapy, and (*c*) reviewed the SOP for diagnostic and therapeutic LPs. Participants then proceeded to the third station, a psychomotor skill station, where they demonstrated their postintervention evaluation of diagnostic and therapeutic LP skills on an adolescent simulator that provided a flashback of CSF. A member of the expert panel then evaluated each participant at this station again using the procedure skill checklist. Each participant was evaluated by the same expert panel member across the 2 simulation stations in order to maintain continuity and interrater reliability. The third station used 2 experts, one at the bedside to provide real-time debriefing, and the other in the control room. Videotaping of the third station was done to check for accuracy of the psychomotor skills checklist.

At the third station participants were given either an incorrectly tagged simulated chemotherapy syringe or an incorrect transport bag. The purpose of this step was to evaluate the participant's sensitivity to a potential sentinel event and test for confirmation bias. Nickerson (1998) refers to confirmation bias as the notion that people are prone to "treat evidence in a biased way when they are motivated by the desire to defend beliefs that they wish to maintain" (p. 176).

Analysis

IBM SPSS Version 20 Statistical Software was used for statistical analysis. The goal was to evaluate the impact of the simulation procedure competency in the skills of diagnostic and therapeutic LP for a targeted team of physicians and NPs who do not routinely perform this skill but are required to maintain this competency. Outcomes included changes in anxiety, confidence, and psychomotor skill accuracy. Descriptive statistics were used to

Table 3. Summary of Standard Operating Procedure and Practice Recommendations for Diagnostic Lumbar Puncture and Therapeutic Lumbar Puncture.

Psychomotor skills checklist for diagnostic lumbar puncture (LP) procedure
Time out called—check correct procedure against patient armband
Put on face mask
Wash/disinfect hands
Assure best patient positioning/alignment (lateral recumbent position if measuring opening intracranial pressure, under conscious sedation, or general anesthesia; sitting position is acceptable for diagnostic LP in awake patients)
Palpate the superior aspects of the iliac crest (intersects the midline at the L4 spinous process)
Palpate lumbar processes before prepping and draping
Mark area between lumbar processes (thumb nail imprint or surgical marker)
Open LP tray and put on sterile gloves
Apply skin prep with betadine (allow to dry) or chlorahexadine using a pattern of widening concentric circles for 3 separate applications
Use a topical local anesthetic or subcutaneous injection of a local anesthetic with 1% buffered Lidocaine using a 25-gauge needle (optional—not often used if the patient is sedated; buffered Lidocaine prepared by pharmacy)
Place drapes to create a sterile field
Prepare cerebrospinal fluid (CSF) collection tubes and manometer (if measuring opening pressure)
Choose correct needle gauge and length
Palpate iliac crest while finding interspace (marked accordingly)
Advance needle at proper site (between L3 and L4 or L4 and L5 spinous processes) and angle (15° aiming at the patient's umbilicus) facing toward the patient's head with bevel perpendicular with longitudinal fibers
Intermittently remove stylet to check for CSF
Measure opening pressure by attaching 3-way stopcock and manometer (if indicated)
Obtain CSF for studies
Measure closing pressure (if indicated and for diagnostic LP only)
Replace stylet (if diagnostic LP only)
Remove needle in one slow steady motion (diagnostic LP only)
Apply sterile dressing
Maintain sterile technique throughout procedure

Psychomotor skills checklist for therapeutic lumbar puncture (LP) procedure
Time out called—check correct procedure against patient armband
Check chemotherapy against pharmacy order and patient armband
Put on face mask
Wash/disinfect hands
Assure best patient positioning/alignment (lateral recumbent position)
Palpate the superior aspects of the iliac crest (intersects the midline at the L4 spinous process)
Palpate lumbar processes before prepping and draping
Mark area between lumbar processes (thumb nail imprint or surgical marker)
Open LP tray and puts on sterile gloves
Apply skin prep with betadine (allow to dry) or chlorahexadine using a pattern of widening concentric circles for 3 separate applications
Use of a topical local anesthetic or subcutaneous injection of a local anesthetic with 1% buffered Lidocaine using a 25-gauge needle (optional—not often used if the patient is sedated; buffered Lidocaine prepared by pharmacy)
Place drapes to create a sterile field
Chose correct needle gauge and length
Palpate iliac crest while finding interspace (marked accordingly)
Advance needle at proper site (between L3 and L4 or L4 and L5 spinous processes) and angle (15° aiming at the patient's umbilicus) facing toward the patient's head with bevel perpendicular with longitudinal fibers
Intermittently remove stylet to check for cerebrospinal fluid (CSF)
If administering intrathecal (IT) chemotherapy, either remove CSF equal to at least one half to the total volume of IT chemotherapy volume, or remove no more than 1 mL/kg to a maximum of 30 mL)
Administer chemotherapy (either by attaching chemotherapy syringe directly to the LP needle and carefully stabilizing syringe while administering chemotherapy, or by attaching a short extension tubing allowing for CSF to drain to hub, attach chemotherapy followed by additional saline to purge extension tubing or watch for a small bubble to stop at the hub)
Do not replace stylet, instead without detaching the syringe, remove LP needle with syringe attached using one slow steady motion
Apply sterile dressing
Maintain sterile technique throughout procedure
Instruct patient to lie flat for 30 minutes after chemotherapy administration to allow for maximal distribution of chemotherapy

Table 4. Anxiety Scores.[a]

Provider	Presimulation Procedure Anxiety, Mean (SD)	Presimulation Step Anxiety, Mean (SD)
Combined (n = 14)	3.21 (1.37)	2.64 (2.41)
Physician (n = 5)	3.60 (.89)	3.40 (.89)
Nurse practitioner (n = 9)	3.00 (1.58)	3.00 (1.58)
Provider	**Postsimulation Procedure Anxiety, Mean (SD)**	**Postsimulation Step Anxiety Mean (SD)**
Combined (n = 14)	3.79 (1.05)	2.14 (1.92)
Physician (n = 5)	4.20 (.44)	3.80 (.44)
Nurse practitioner (n = 9)	3.56 (1.23)	3.33 (1.11)
Sample	**Overall Anxiety**	**Specific Step Causing Anxiety**
Combined (n = 14)	$t = -1.973$, $P = .09$	$t = .979$, $P = .346$

Abbreviation: SD, standard deviation.
[a]Descriptive statistics—means (SDs). The scores represent self-reported anxiety scale using a 5-point Likert-type score, ranging from 1 (*extremely anxious*) to 5 (*no anxiety*). Inferential statistics—paired *t* tests.

describe the sample using mean, standard deviation, and percentages. Inferential statistics were used to compare means between pre- and postanxiety measures, pre- and postconfidence measures, and psychomotor skills checklist total scores. The groups were stratified by provider type. The videotapes were reviewed by the primary investigator to validate the psychomotor skills check-off.

Results

The pre- and postanxiety scale employed a reverse polarity scaling compared with the confidence scales (for the anxiety measure, the higher the Likert-type score, the less the anxiety). For the confidence measure, the higher the Likert-type score, the higher the confidence). The anxiety scale had 2 items using a 5-point Likert-type scale, ranging from 1 (*extremely anxious*) to 5 (*no anxiety*). The first item rated overall anxiety for performing a diagnostic or therapeutic LP. The second item rated anxiety related to a specific step in the LP procedure. It also included an open-ended question to identify key concepts. Using a paired *t* test, there was a nonsignificant decrease in anxiety scores for combined physician and NP scores following the simulation experience $t = -1.847$, $P = .09$. A summary of the scores and standard deviations are provided in Table 4.

In the presimulation open-ended question to identify which specific step caused the most anxiety, 43% of participants identified "obtaining a clear tap" as the cause for the most anxiety with 21% citing "incorrect placement/missing landmarks" and 21% "causing pain/injury" as the next most frequent cause of anxiety. Fourteen percent of the participants did not identify any specific step causing anxiety. One respondent listed 3 specific items that made him or her anxious. The first response was listed as the primary response.

In the postsimulation open-ended question to identify which specific step caused the most anxiety, several participants gave more than 1 answer. Most responses were similar except for 1 respondent who identified an additional step of making a "chemo mistake" in addition to his or her primary response. Another respondent identified the "manometer" step as causing anxiety. Itemized responses are captured in Table 5.

Provider confidence was measured using a 3-item, 5-point Likert-type scale, ranging from 1 (*not very confident*) to 5 (*very confident*). The confidence items measured overall confidence with the LP procedure, confidence in measuring intracranial pressure using a manometer, and confidence in administration of IT chemotherapy. Using a paired *t* test, confidence in measuring ICP did show statistically significant change between the premeasures and postmeasures $t = -2.92$, $P = .013$. Combined overall confidence with the LP procedure showed a statistically significant change between pre- and postmeasures $t = -2.132$, $P = .05$, as did the administration of IT chemotherapy $t = -2.144$, $P = .05$. Overall, confidence improved in all items from the pre to postmeasure. Table 6 shows the mean and standard deviations across the physician and NP groups.

Psychomotor skills checklist for knowledge was measured using a 20-item checklist derived from the SOP. The expert panel used a consensus method to weight the steps of the checklist based on the level of complexity. The total weight of 17 points was dispersed across 14 steps at a weight of 1.0 and 6 steps at a weight of 0.5. There was no statistically significant difference between the pre and postchecklist total mean scores. There were 8 steps that showed a perfect check-off score at both stations 1 and 3. These steps have been removed from Figure 1 to highlight those steps with differences in pre and postscores.

Table 5. Specific Step Anxiety.[a]

Provider-Identified Anxiety	Presimulation, n (%)	Postsimulation, n (%)
"No clear tap"	6 (42.9)	7 (50)
"Incorrect placement" or "Missing the landmarks"	3 (21.4)	4 (28.6)
"Causing pain/injury"	3 (21.4)	1 (7.1)
"Measuring ICP"	0 (0.0)	1 (7.1)
No specific anxiety identified	2 (14.3)	1 (7.1)

Abbreviation: ICP, intracranial pressure.
[a]This chart lists the answer to the open-ended question on anxiety to identify key concepts about which step caused the most anxiety.

Table 6. Confidence Scores.[a]

Provider	Presimulation Overall Confidence, Mean (SD)	Presimulation Confidence of ICP, Mean (SD)	Presimulation Confidence for Administration of Chemotherapy, Mean (SD)
Combined (n = 14)	3.77 (1.6)	2.92 (1.4)	3.38 (1.6)
Physician (n = 5)	4.80 (.44)	3.60 (.54)	4.20 (1.30)
Nurse practitioner (n = 9)	3.13 (1.72)	2.50(1.69)	2.88 (1.64)
Provider	**Postsimulation Overall Confidence, Mean (SD)**	**Postsimulation Confidence of ICP, Mean (SD)**	**Postsimulation Confidence for Administration of Chemotherapy, Mean (SD)**
Combined (n = 14)	4.15 (1.1)	3.63 (1.2)	3.85 (1.3)
Physician (n = 5)	4.80 (.44)	4.20 (.44)	4.40 (.89)
Nurse practitioner (n = 9)	3.89 (1.26)	3.22 (1.20)	3.67 (1.41)
Sample	**Overall Confidence**	**Confidence Measuring ICP**	**Confidence in Administration of Chemotherapy**
n = 14	$t = -2.132$, $P = .054$	$t = -2.92$, $P = .013$	$t = -2.144$, $P = .053$

Abbreviations: SD, standard deviation; ICP, intracranial pressure.
[a]Descriptive statistics—means (SDs). The scores represent self-reported confidence scale using a 5-point Likert-type score, ranging from 1 (*not very confident*) to 5 (*very confident*). Inferential statistics—paired *t* tests.

The chemotherapy step of the psychomotor skills checklist tested whether or not the participant performed the proper checks of the chemotherapy prior to administration. For station 3, a medication error was designed to test for confirmation bias. Despite prior review of the pharmacy policy for dispensing IT medication, the chemotherapy check step was missed by 7 out of the 14 participants representing 50% of the sample.

Measuring ICP using a manometer was a frequent missed step. Only 5 (36%) participants demonstrated this step during station 1; however, these data are difficult to interpret. Because the simulation occurred over 3 separate dates there was some variation in the instruction given for this step of the procedure across sessions. The second missed step for both pre- and postsimulation was hand washing. The lack of attention to hand washing as a basic but critical step in this procedure has significant implications to patient safety. The top 3 missed steps for the pre- and postsimulation psychomotor checklists are listed in Table 7.

Participants were asked to complete a postsimulation survey to evaluate the usefulness of the experience. The survey used a 5-point Likert-type scale where 1 = *strongly disagree* and 5 = *strongly agree*. Scores suggest that the experience was helpful, realistic, and reported to increase clinical confidence (see Table 8).

Discussion

The purpose of this project was to design, implement, and evaluate a process for maintaining competency and standardized practice of the IT access skill set across health care providers using simulation. The results of this study demonstrated nonsignificant improvement in anxiety scores. It is possible that participants may have felt more comfortable with either the adolescent or the pediatric

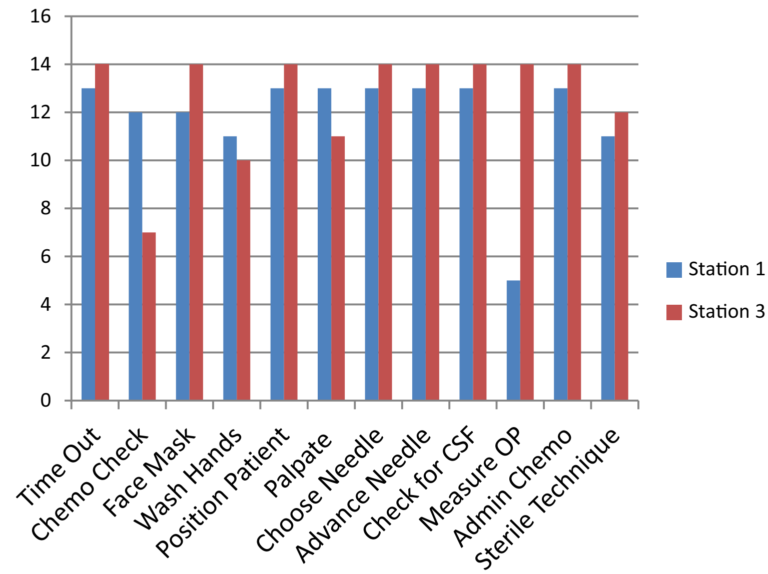

Figure 1. Number of providers who correctly performed each item.
The *X*-axis represents the steps assessed excluding those steps that had perfect scores pre and post. The *Y*-axis represents the number of providers correctly performing steps.

Table 7. Top Missed Items on Psychomotor Skills Checklist.[a]

Presimulation Psychomotor Skills Checklist	Postsimulation Psychomotor Skills Checklist
Measuring intracranial pressure (9/14), 64%	Checked chemotherapy (7/14), 50%
Wash/disinfect hands (3/14), 21%	Wash/disinfect hands (4/14), 29%
Maintain sterile technique throughout procedure (3/14), 21%	Palpate lumbar processes before prepping and draping (3/14), 21%

[a]The top missed items (number of providers who missed step/sample size), percentage missed.

simulator which may have affected anxiety scores pre- and postprocedures. There were statistically significance differences in confidence scores with measuring ICP using a manometer, with overall confidence and with confidence in administering IT chemotherapy. This quality improvement project was implemented to standardize the skill set for a high-risk procedure and to enhance health care provider competencies using simulation as a strategy to promote patient safety and reduce variations in existing practice patterns. There are 2 important themes that can be gleaned from this simulation with regard to patient safety. The first is in regard to skill decay. The demographic information obtained from the sample prior to the simulation revealed that 21% and 27% of the health care providers had not performed a diagnostic LP or therapeutic LP, respectively, within the past year. Given the Arthur et al. (1998) definition of skill decay becoming problematic after a lapse of 365 days, the LP procedure in this population is at high-risk for decay. A structured competency skills simulation provides an opportunity for providers to practice their skills in the absence of opportunity to perform these in their clinical practice; thereby possibly ameliorating the effects of skill decay.

A second important theme relates to confirmation bias. The most striking finding of this simulation exercise involved the medication error designed during station 3. The error was missed by 50% of the participants who had the opportunity during the simulation to review the chemotherapy, transport bag, and chemotherapy order. The pharmacy policy, including dosing, ordering process, general information (expiration, dilution, total volume), the tagging of chemotherapy, transporting in color coded labels and bag, and pharmacy dispensing rules were reviewed at station 2. The education intervention was designed to review the importance of performing medication checks of the chemotherapy to include checking the chemotherapy against the order and to affirm that the chemotherapy was appropriately tagged or in the appropriate transport bag. At both simulation stations, the participants were given the simulated chemotherapy syringe in a

Table 8. Means and Standard Deviations (SD) for Satisfaction Survey.

Survey Item	Mean	SD
I found the pediatric lumbar puncture (LP) skill station to be helpful	4.50	0.76
I found the adolescent LP skill station to be helpful	4.42	0.76
The environment in which the scenarios were done is realistic	4.42	0.76
Things I learned during the simulation will help improve my clinical skills	4.50	0.65
Things I learned during the simulation will help my overall confidence	4.42	0.64
I think that some simulation-based training is helpful in maintaining competencies	4.64	0.63

transport bag with the chemotherapy order and asked to treat the procedure and chemotherapy as they would if this were their clinical practice. It is possible that the correct chemotherapy at the first station gave a false sense of reassurance that they would be given the correct chemotherapy at the third station; however, in clinical practice this also may be true. Perhaps the participants who participated in the simulation are yet to experience an incorrect pharmacy order or incorrect labeling of chemotherapy during their clinical practice. The actual experience of missing this step at the third station seemed to be of very high value. It appears that the health care providers who missed the error treated the chemotherapy in a biased way by assuming that the intended chemotherapy handed to them was dispensed correctly by the pharmacy. In a clinical setting, if the provider operated on this confirmation bias, a significant error would have occurred causing potential patient harm. This simulation exercise provided an opportunity for providers to miss the chemotherapy check and to experience this potentially fatal error during a simulation without any danger to patients in the clinical setting. While translation of this is difficult to quantify, it is likely that providers who missed this medication error will be more vigilant about this step the next time they perform a therapeutic LP.

The chemotherapy checks worsened following the education intervention, yet the confidence level of the participants improved. It is possible that the providers may have felt more confidence with the psychomotor aspects of the procedure following the simulation at 2 different stations. The fact that this was a simulation and not a real clinical situation may have affected how they responded in the postsimulation confidence scales.

Limitations

Despite a range of recruitment strategies and flexibility in simulation scheduling, our sample size was small. Our small sample size likely impacted our ability to detect statistically significant differences across the stations. We began with a group of committed individuals who served as experts at each of the stations; however, scheduling conflicts resulted in some last-minute substitutions of expert evaluators. This may have affected the continuity of instruction given at station 3. Finally, the instruction given by the expert evaluators at the psychomotor skills stations was a learning curve and improved with each simulation.

Conclusion

The development of a process of skill standardization through the use of simulation for enhancing health care provider competencies in a sample of experienced clinicians is an innovative method to promote patient safety, and reduce variability of practice patterns for diagnostic and therapeutic LPs. The simulation experience gives the provider the opportunity to demonstrate skills that they may not have had an opportunity to perform over time. Given the positive response to the postsimulation survey, the simulation was found to be helpful in maintaining competencies indicating that this was not just an exercise to the experienced provider, but rather a valued experience in the clinical practice. In addition to a simulation experience serving as a way to document annual competencies, this specific simulation can serve as a platform for introducing newly developed treatments, such as IT cellular therapy administration. The existence of a simulation teaching model for introducing new innovations of practice will help the health care provider to incorporate new skills into current practice and provide the organization with a method to ensure that a high-risk skill is introduced with the goal of ensuring patient safety.

Declaration of Conflicting Interests

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