INNOVATION AND IMPROVEMENT

Hybrid Simulation for Knee Arthrocentesis: Improving Fidelity in Procedures Training

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BACKGROUND: Procedures form a core competency for internists, yet many do not master these skills during residency. Simulation can help fill this gap, but many curricula focus on technical skills, and overlook communication skills necessary to perform procedures proficiently. Hybrid simulation (HS) is a novel way to teach and assess procedural skills in an integrated, contextually-based way.

AIM: To create a HS model for teaching arthrocentesis to internal medicine residents.

SETTING: Internal medicine residency program at the University of Toronto.

PARTICIPANTS: Twenty four second-year internal medicine residents.

PROGRAM DESCRIPTION: Residents were introduced to HS, given practice time with feedback from standardized patients (SPs) and faculty, and assessed individually using a different scenario and SP. Physicians scored overall performance using a 6-point procedural skills measure, and both physicians and SPs scored communication using a 5-point communication skills measure.

PROGRAM EVALUATION: Realism was highly rated by residents (4.13/5.00), SPs (4.00) and physicians (4.33), and was perceived to enhance learning. Residents' procedural skills were rated as 4.21/6.00 (3.00 – 5.00; ICC = 0.77, [0.53 – 0.92]), comparable to an experienced post-graduate year (PGY) 2-3; and all but one resident was considered competent.

DISCUSSION: HS facilitates simultaneous acquisition of technical and communication skills. Future research should examine whether HS improves transfer of skills to the clinical setting.

Electronic supplementary material The online version of this article (doi:10.1007/s11606-012-2314-z) contains supplementary material, which is available to authorized users.

Received March 24, 2012

Revised August 21, 2012

Accepted December 6, 2012

Published online January 15, 2013

KEY WORDS: medical education; postgraduate; assessment methods; simulation; communication skills; clinical skills training.

J Gen Intern Med 28(5):723–7

DOI: 10.1007/s11606-012-2314-z

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INTRODUCTION

Performing bedside procedures is a core competency for internists.^{1,2} However, many residents do not master procedural skills during their training.^{3,4} Residents report too little experience,^{5,6} being uncomfortable with,^{5–7} and receiving limited faculty observation and feedback on procedures.⁷ As a result, new curricula are being developed to improve procedural training in residency programs.^{8–10}

Many new curricula incorporate simulation, in addition to real-patient encounters.^{9,10} However, simulation is often limited to bench models and focuses exclusively on technical skills and procedural steps.^{9–11} Internal medicine residents have identified lack of realism as a barrier to learning procedures on a simulator.¹¹ Recent literature has highlighted the importance of context on learning, and called for a more patient-focused approach to simulation. This ensure that all skills necessary for successful procedural performance are learned prior to exposure to real patients.^{12–14} There is also growing evidence that progressively higher simulation fidelity may lead to greater transfer of skills.¹⁵ Fidelity applies not only to the technology, but also to the degree to which the overall simulation setting replicates the clinical context.

Figure 1. Example of an arthrocentesis bench model simulator and an arthrocentesis hybrid simulation.

Hybrid simulation (HS) is a novel method to teach and assess technical and communication skills in an integrated fashion,^{16,17} and has been previously implemented in undergraduate and surgical training.^{17–19} In HS, a clinician interacts with a patient, portrayed by a standardized patient (SP), while performing a procedure on a bench model that has been realistically affixed to the SP. This format bridges the gap between isolated technical proficiency on a bench model and overall procedural proficiency required in the real world, providing a contextually based way to teach and assess technical and communication skills prior to performing clinical procedures. Furthermore, it allows for variations in difficulty and complexity in the clinical scenario, so that trainees can be presented with a more demanding simulation even after achieving technical proficiency, before they encounter challenging situations in the real world. Additionally, the added cognitive load may unmask relative deficiencies in procedural skills that are not manifested when the overall clinical context is not as challenging.

This pilot study introduced HS into the internal medicine training program at the University of Toronto. Our goals with the HS were to: 1) measure residents' performance using a procedural skills measure; 2) compare communication items within the procedural skills measure (scored by physicians) to another communication skills measure (scored by physicians and SPs); and 3) survey residents, physicians, and SPs about the use of HS for procedural skills learning.

SETTING AND PARTICIPANTS

The didactic procedures curriculum in the University of Toronto Internal Medicine residency program consists of two half-day sessions during the post-graduate year (PGY) 1, in which residents receive instruction and hands-on training using bench model simulators. For the present study, a convenience sample of 24 PGY2 residents participated in the HS session during an academic half-day. The study was approved by the University of Toronto Research Ethics Board and all residents provided consent.

PROGRAM DESCRIPTION

After a short orientation to HS, residents were divided into groups of four and paired with a SP and a physician facilitator. They received practice and feedback on the hybrid arthrocentesis simulation, a bench model arthrocentesis simulator attached to a SP (Fig. 1), for one hour. Because of technical limitations, residents were instructed to use the lateral approach and to assume local anesthesia had been given. They completed all other aspects of the procedure, including obtaining informed consent.

Following the practice phase, residents participated individually in a 10-minute assessment exercise using a new scenario (Text Box 1) with a different SP and physician rater (MD1). All procedures completed during the assessment exercise were videotaped for analysis by the two physician investigators, MD2 and MD3.

Text Box 1.

You are seeing Mrs. Williams in the ER.

You have completed your preliminary assessment and have learned:

HISTORY:

- Mrs. Williams is a completely healthy 40 year-old female
- Past medical history negative, no medications, no allergies
- 3 days ago she tripped while gardening and cut her left leg at the mid-shin.
- She washed it out, applied some polysporin, and put a band-aid on it.
- She awoke this morning with a painful, swollen left knee and felt feverish.

EXAM:

- Vitals signs stable, fever 38.4C (101.1F)
- Effusion with warmth and erythema of left knee, small laceration left shin
- Remainder of exam normal

INVESTIGATIONS:

- WBC 14.5×10^9
- All other bloodwork (including INR and PTT) normal

You suspect that Mrs. Williams may have septic arthritis.

You now plan to perform an arthrocentesis.

Physicians used a procedural skills measure to assess trainees' procedural skills along a 6-point scale (Appendix 1, available online). This instrument, modified for this specific procedure, was developed by Kneebone¹⁷ based largely on the Direct Observation of Procedural Skills (DOPS) form,²⁰ and has been demonstrated to have construct and criterion validity.^{18,21} For this study, numerical scores on this scale were anchored to performance ranging from a clerk (1/6, inadequate technical skill, and difficulty with simultaneous communication) to a consultant (6/6, flawless technique without hesitation and with smooth transitions, whilst engaging and reassuring the patient). The mid-range of the scale was anchored as an experienced PGY 2-3 (safe and successful procedure, with only minor technical problems, and able to concurrently communicate with the patient when necessary). Residents also received a global "competency" score. Both physicians and SPs rated a separate communication skills measure, established to have construct validity,²² to assess residents' communication skills on a 5-point scale across five domains, and a global rating (Appendix 2, available online).

SPs provided the residents with immediate feedback about their communication skills after the procedure. The six SPs involved were all members of the Standardized Patient Program at the University of Toronto, and all have extensive training and experience in providing communication feedback to trainees at multiple levels. Prior to

the session, they received 2 hours of training for their role, facilitated by a senior SP educator who was involved in the planning, development, and execution of the sessions.

After the entire session, residents, SPs, and physicians all completed 5-point scale surveys about their experiences, and the researchers also sought informal feedback from the residents.

Descriptive statistics (mean, range) were calculated for the physicians' ratings on the procedural skills measure, and for both physicians and SPs on the communication skills measure. The inter-rater reliability between the two physician researchers who viewed the videotapes was calculated using an Intraclass Correlation Coefficient (ICC (2,1)) for both scoring measures. Pearson's correlation coefficient was used to explore the relationship between scores on the communication items from the procedural skills measure (sum of items 1, 2, 3, 11, 12) and the individual items on the communication skills measure.

PROGRAM EVALUATION

Prior to this session, many of the residents had experience with knee arthrocentesis. Nine (of 24) had previously performed an arthrocentesis on a bench model (15/24 had not), and 20 had previously performed at least one arthrocentesis in the clinical setting (1 = 6/24; 2 = 3/24;

3 = 7/24; 4 = 4/24). Three residents had never previously performed an arthrocentesis on either a bench model or real patient.

The residents' overall performance on the assessment scenario was rated as 4.21/6.00 (range = 3.00 – 5.00) by the physician (MD1) rater present on the day of simulation, higher than by MD2 (3.71; range = 3.00 – 4.00) and MD3 (3.78; range = 3.00 – 5.00) on videotape review. Inter-rater reliability of the procedural skills measure was substantial (ICC = 0.77, [0.53 – 0.92]). These ratings corresponded to an anchor of approximately an experienced PGY 2-3. Only one resident was judged to be "borderline"; this was due to issues with obtaining informed consent. The remainder of the residents were all rated as competent.

On the communication skills measure, residents were consistently rated higher by the SP (4.21/5.00 overall) than by the physicians (MD2 = 4.00, MD3 = 3.87; range for all = 3.00 – 5.00), with similar pattern of results for the communication sub-scores (results not shown). The communication skills measure showed substantial inter-rater reliability (ICC = 0.89 [0.82 – 0.95]). The correlation between scores on the communication skills measure and the sum of the communication-specific items on the procedural skills measure was fair to moderate (Pearson's rho 0.36-0.67).

On post-simulation surveys and informal debriefing, the arthrocentesis HS for the PGY2s was felt to be a valuable exercise teaching and assessing communication and procedural skills by all involved. Realism was highly rated by residents (4.13/5.00), SPs (4.00) and physicians (4.33), and this was perceived to enhance teaching and performance of communication skills and attention to the "whole" procedure. In comparison to a bench model residents commented, "It better resembles a "real-life" scenario and reveals gaps and areas to improve on" and "(standardized) patient interaction made it feel like a real clinical encounter".

Residents and SPs valued the immediate feedback on communication style and content. Specific feedback focused on explaining the purpose of the procedure and obtaining informed consent, including alternatives. While technical skills were taught in the practice phase, immediate feedback on technique was not given in the assessment phase. Residents requested adding technical skills feedback to enhance the educational benefit.

DISCUSSION

There is growing recognition of the need to improve procedural training within internal medicine residency programs, often driven by trainees. Many new curricula are evolving, with simulation playing a major role.

However, there is a gap between bench model simulators and bedside procedures on real patients. HS affords the ability to bridge this gap with progressive levels of simulation fidelity before moving onto clinical procedures.

Our study is one of the first to implement and examine the use of HS within internal medicine. We found that, despite having prior experience with knee arthrocentesis, residents rated the use of HS for this skill as realistic and useful. They valued practicing and being assessed on the procedure as a whole, rather than just on technical skills, as it "more resembles real life". Our approach is in line with calls to acknowledge and incorporate greater realism and authenticity in simulation.¹²⁻¹⁴

There were several limitations to our study. This is a single centre study and its findings may not apply to different educational contexts. We also did not include an evaluation of transfer of skills to the clinical setting or the impact on patient outcomes in this pilot study. In addition, our analysis was somewhat restricted by unavailable data. Despite pilot testing our video equipment and set-up, the camera angles meant that some segments of some residents' performance were obscured on the final videotapes, and therefore videotape raters were unable to score them. We considered this a valuable lesson learned, and in the future will use dual cameras, one head-camera for the resident for detailed technical data and one camera for the overall encounter, for optimal viewing and data collection.

In addition to these limitations, an important consideration with any simulation-based intervention is cost. Simulation is expensive, especially HS for which both bench models and trained SPs are needed. Costs include purchase of bench-top models, training and actual simulation time for SPs, and faculty time for scenario development and resident assessment. However, in light of increasing evidence that simulation is effective in improving skills^{23,24} and growing attention to patient safety, there is an ethical imperative to provide greater training prior to gaining experience on patients.²⁵ Simulation therefore must be used judiciously and in a manner that maximizes benefit and minimizes unnecessary expenditures. Many of our trainees already had experience with arthrocentesis, largely in the clinical setting. Our HS exercise should ideally be introduced earlier in training, a suggestion made by the participants.

Graduated fidelity is one approach to help manage costs.. For example, very early in training, at the start of internship (or even earlier), training on bench models alone may suffice for technical skills. Through self-regulated learning, trainees themselves may be able to identify when they have mastered technical skills and are able to progress¹⁵ to perform the procedure on a hybrid simulator. Initially, SPs may portray a straightforward patient interaction. Once

trainees master this skill, more challenging scenarios can be introduced, allowing for graduated difficulty in the communication scenario to be matched with increasing technical expertise.

Overall, our pilot demonstrated that HS may be effectively incorporated into our procedural training program. Future directions include expanding this experience to other procedures; building a program of procedural teaching and assessment that permits increasing the cognitive load of the simulated scenario, prior to independent real-world practice; studying HS among more advanced learners; and assessing the impact on patient care and patient outcomes.

Acknowledgements:

Contributors: We would like to thank Diana Tabak and Karen Delaney-Laupacis from the Standardized Patient Program for their assistance in planning and executing the session.

Funders:

This study was funded by a grant from the Department of Medicine Professors Research and Education Fund, University of Toronto and the Education Development Fund, Faculty of Medicine, University of Toronto; a 25th Anniversary Project Award from the Standardized Patient Program, University of Toronto; and Herbert Ho-Ping-Kong Centre for Excellence in Education and Practice.

Prior presentations:

Preliminary results from this study were presented at the RCPSC International Conference on Residency Education in Ottawa on September 24, 2010.

Conflict of Interest: The authors declare that they do not have a conflict of interest.

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