Fibreoptic airway training: correlation of simulator performance and clinical skill

[Formation en gestion des voies aériennes par fibre optique : corrélation entre la performance en simulateur et les habiletés cliniques]

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Purpose: Simulation centres, where trainees can practise technical procedures on models of varying fidelity, provide a training option that allows them to acquire skills in a controlled environment prior to clinical performance. It has been proposed that the time to complete a simulator task may translate to proficiency in the clinical setting. The objective of this study was to determine whether time to complete a simulator task translates to clinical fibreoptic manipulation (FOM) performance.

Methods: Thirty registered respiratory therapists at a teaching hospital were recruited as subjects for a single-blinded randomized trial. Subjects were randomized to training on either a low fidelity (n = 15) or high fidelity (n = 15) model. After training, each subject was tested for the time required to complete a specific task on his/her respective model. Subjects then performed a fibreoptic orotracheal intubation (FOI) on healthy, consenting, and anesthetised patients requiring intubation for elective surgery. Performance was measured independently by blinded examiners using a checklist and global rating scale (GRS); and time was measured from insertion of the fibreoptic scope to visualization of the carina. Data were analyzed using Spearman rank order correlation coefficients.

Results: There was no correlation between the time to complete a task on either the high or low fidelity simulators, and the clinical FOI performance as assessed by a checklist, GRS, and time to complete the FOM (all P = NS).

Conclusion: These results suggest that simulator-based, task-orientated time measurement may not be a good indicator of FOI performance in the clinical setting.

CAN J ANESTH 2008 / 55: 2 / pp 100–104

Objectif *: Les centres de simulation, où les stagiaires peuvent s'exercer à réaliser des gestes techniques sur des modèles d'une fidélité variable, constituent une alternative de formation qui leur permet d'acquérir des compétences dans un environnement contrôlé et ce, avant de travailler dans un environnement clinique. Il a été suggéré que le temps nécessaire à compléter une tâche dans un simulateur pourrait refléter l'aptitude dans un contexte clinique. L'objectif de cette étude était de déterminer si le temps utilisé pour compléter une tâche dans un simulateur se traduisait en performance de manipulation fibroscopique (FOM) clinique.*

Méthode *: Trente inhalothérapeutes certifiés oeuvrant dans un hôpital universitaire ont été recrutés pour participer à cette étude randomisée en simple aveugle. Les sujets ont été randomisés à s'entraîner soit avec un modèle peu fidèle (n = 15) ou très fidèle (n = 15). Après la formation, chaque sujet a été testé par rapport au temps requis pour compléter une tâche spécifique sur son modèle respectif. Les sujets ont ensuite réalisé une intubation orotrachéale par fibroscopie (FOI) sur des patients sains, consentants et anesthésiés nécessitant une intubation pour une chirurgie élective. La performance a été mesurée de façon indépendante par des examinateurs en aveugle à l'aide d'une liste de contrôle et une échelle d'évaluation générale (GRS) ; le laps de temps écoulé entre l'insertion du fibroscope et la visualisation de la carène a été mesuré. Les données ont été analysées à l'aide des coefficients de corrélation des rangs de Spearman.*

Résultats *: Il n'y a pas eu de corrélation entre le temps nécessaire à compléter une tâche sur les simulateurs, qu'ils soient très fidèles ou peu fidèles, et la performance d'intubation par fibroscopie telle que mesurée par une liste de contrôle, le GRS, et le temps pour effectuer la FOM (tous P = NS).*

Conclusion *: Ces résultats suggèrent que le chronométrage basé sur simulateur et centré sur la tâche ne constitue pas un bon indice de la performance de FOI dans un contexte clinique.*

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Study performed at St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada.

Accepted for publication October 17, 2007.

Revision accepted November 19, 2007.

FIBREOPTIC orotracheal intubation (FOI), internationally accepted as an important tool in the management of the difficult airway,[1,2] is an essential skill in anesthesiology. Traditionally, this skill was taught exclusively in the operating room. Increasing time constraints, secondary to altered working practices and production pressures in the operating room, have led to reduced opportunity to teach and to practise this skill in the clinical setting.[3,4]

To overcome this barrier to training, simulators, which attempt to replicate the clinical environment, have been developed and can aid the acquisition of fibreoptic manipulation (FOM) skills outside of the operating room. Both high and low fidelity models have been shown to improve the acquisition of the technical skills required for FOI, when compared with conventional didactic instruction.[5–7] Correspondingly, several surgical studies have demonstrated that laparoscopic surgical skills improve when practised on bench and virtual reality part-task simulators.[8,9] Specifically, in randomized controlled trials, technical performance improved significantly more in groups trained on simulators when compared with conventionally trained groups.[10,11] There is clear cross-specialty evidence that part-task simulators are effective at training clinical technical skills; and that they increase skills more effectively than traditional teaching paradigms.

Technical skills can be evaluated by several tools initially developed to assess the operative performance of surgical trainees and recently adapted for use in anesthesiology.[12] Checklists and global rating scales (GRS) are both valid and reliable means of assessing clinical technical skills such as fibreoptic scope manipulation.[13–15]

Time has also been used to assess technical skills. The time to complete a simulator task has been assumed to translate into clinical skill, with a rapid completion of task correlating with increased clinical proficiency. No investigation has assessed whether simulator, task-based time measurement is useful in confirming if, and to what extent, trainees are likely to be proficient in the clinical setting.

The primary objective of this study was to determine whether the time to complete a fibreoptic scope manipulation task on simulators of varying fidelity translates into clinical FOM skill when assessed by a GRS, checklist, and time to visualization of the carina. A secondary objective was to assess whether time to visualization of the carina correlates with objective measures of clinical FOM skill.

Methods

After obtaining Institutional Review Board approval of the study protocol and informed consent from each participant, 30 registered respiratory therapists (RRTs) were recruited as subjects at a teaching hospital for a randomized single-blinded trial. Eligibility criteria included all RRTs who work at St. Michael's Hospital. Registered respiratory therapists are a useful surrogate for trainee anesthesiologists because of their familiarity with FOI equipment and airway anatomy and their lack of bronchoscopy experience. Subjects were excluded if they had independently completed two or more fibreoptic bronchoscopes.

Subjects were randomized using a computerized random number generator to receive training on a low fidelity (n = 15) or high fidelity (n = 15) model. Allocation concealment was accomplished by use of sealed opaque envelopes. One subject from each group failed to receive training due to logistical problems.

Prior to either training modality, all subjects received basic, standardized oral and written instructions on how to manipulate a fibreoptic scope (5 mm Pentax, Mississauga, ON, Canada). The low fidelity group was trained on a simple, non-anatomic box model designed to refine fibreoptic skills.[6] The high fidelity group practised on a computerized, virtual reality bronchoscopy simulator (Accutouch® endoscopy simulator, Immersion Medical, Gaithersburg, MD, USA). Subjects were allowed up to one hour to practise fibreoptic scope manipulation by attempting different tasks on their respective models. Informal feedback was provided by an expert bronchoscopist who was in attendance. At the end of the training session, each subject was tested on the time taken to complete a similar, but unrelated, specific task on her/his respective model.

In the week following the training session, all subjects performed a FOI on healthy, consenting, and anesthetised patients requiring tracheal intubation for elective surgery. Patient refusal, ASA > 2, body mass index > 25 $kg \cdot m^{-2}$, and potentially difficult airway (Mallampati score > 2) resulted in exclusion. After three minutes of preoxygenation, general anesthesia with muscle relaxation was induced by the attending anesthesiologist using intravenous fentanyl, propofol, and rocuronium. Drugs were administered in doses according to the discretion of the attending anesthesiologist who was not involved in the study. Antisialagogues were not given. The patients' lungs were ventilated with 100% oxygen until loss of twitch response, as assessed by nerve stimulation. Standard monitoring for all subjects included pulse oximetry,

a 5 lead electrocardiogram, and a non-invasive blood pressure monitor.

Two blinded, consultant anesthesiology examiners measured the FOI performance of the subjects, independently for each patient, using a previously described, validated checklist, and a validated global rating scale.[6] Examiners also recorded the time from insertion of the fibreoptic scope at the lips to visualization of the carina. Endotracheal tube insertion was not assessed, as we believe it to be a separate skill from FOM. The final two points on the checklist, relating to passing and confirming placement of the endotracheal tube, were omitted. All subjects were assisted with a jaw thrust from an experienced assistant. If tracheal intubation was unsuccessful within 180 sec, or if the patient's oxygen saturation fell to < 94%, the fibreoptic scope was removed and the performance was deemed a treatment failure. After one minute of manual ventilation with 100% oxygen, a study investigator ensured that failure was not secondary to patient factors and completed intubation of the trachea.

Statistical analysis

Sample size was calculated using an effect size of 1.2 SD. With 12 subjects in each group, using a beta of 0.20 and a two-tailed alpha of 0.05, we had 80% power to detect an effect size of 1.2 SD. Fifteen subjects were recruited to each group to allow for logistical difficulties. Statistical analysis was performed using SigmaStat 3.1 (Systat Software Inc., Chicago, IL, USA). Spearman rank order correlation tests were used to compare the simulator task performance and the clinical performance. Simulator task times were compared to clinical times, checklist scores, and GRS scores. A secondary comparison between clinical FOM time (lips to carina) and GRS and checklist scores was undertaken using Spearman rank order correlation tests. A P value of < 0.05 was considered statistically significant.

Results

Twenty-eight subjects completed the study. In the high fidelity group, six subjects (43%) exceeded 180 sec for task completion and, therefore, failed to complete their clinical FOI. The same number of subjects failed clinical FOI in the low fidelity group. No failure resulted from patient factors, as determined by the study investigators.

There was no correlation between time to task completion on either the high or low fidelity simulators and clinical FOM, when assessed by a checklist, GRS and time to visualization of the carina (all P = NS). The results are summarized in the correlation matrix. (Table II) Inter-rater reliability was strong for checklist scores (r = 0.90) and GRS assessments (r = 0.85).

TABLE I Subject demographics (RRTs)

Characteristic	*Low fidelity training group (n = 14)*	*High fidelity training group (n = 14)*
Male : Female ratio	5 : 9	0 : 14
Age (yr)	33.6 ± 4.3	31.1 ± 6.3
Experience (months as RRT)	82.5 ± 68.2	59.4 ± 54.6
Time on simulator task (min)	31.1 ± 2.7	29.7 ±5.2

RRTs = registered respiratory therapists. All values are mean ± SD unless otherwise noted.

TABLE II Correlation matrix (r_s) of simulator time vs clinical skill

	Low fidelity training	*High fidelity training*
Time	0.25 (0.38)	0.14 (0.63)
GRS	-0.33 (0.24)	-0.16 (0.56)
Checklist	-0.28 (0.32)	-0.20 (0.48)

GRS = global rating scale. *P* values given in brackets.

TABLE III Correlation (r_s) of clinical time to objective measures of clinical skill

	Low fidelity group patient time	*High fidelity group patient time*
GRS	-0.813*	-0.83*
Checklist	-0.823*	-0.746*

GRS = global rating scale; Patient time = lips to carina.
*P < 0.001.

The secondary comparison, between clinical FOM time (lips to carina) and the GRS and checklist scores, showed a significant correlation in both the high and low fidelity groups. (P < 0.001) (Table III).

Although unlikely to affect the results, we note the uneven gender randomization in our subject demographics, with a higher percentage of females in the high fidelity training group. This occurred purely by chance. From previous studies, gender has not been shown to be a predictor of technical skills.[16]

Discussion

The unique aspect of this study is that it examines the correlation of performance measures between simulator-based and clinical attempts of novice personnel undertaking FOI. Performance correlation between settings was not observed, suggesting that simulator-based, task-orientated time measurement may be an insensitive indicator of clinical FOI performance. We

recognize that focusing on outcomes, such as speed of completion of a simulator task, may not capture the nuances of performing procedures on a patient. Instead, ensuring technically sound fibreoptic scope manipulation may be more important. In the non-urgent clinical setting, a slower, technically adept approach to FOI may be beneficial for patients, by avoiding mucosal damage and the associated loss of fibreoptic scope field visualization, and risk of airway obstruction.[17]

Issenberg *et al.*[18] undertook a systematic review of 109 simulator studies, from which they concluded that high fidelity simulation facilitated learning, if accompanied by feedback mechanisms, repetitive practice, and integration with a clinical curriculum. Feedback mechanisms are the most important adjuncts to simulation-based education. Our subjects did not receive the benefit of a formal, structured, feedback system or repetitive practice over an extended period of time. If subjects had been allowed greater time for reflection during a structured debrief, as opposed to simple informal feedback during simulator training, a better correlation may have resulted. Repetitive practice, with simulator sessions extended over a period of time, may have further reinforced newly learned technical skills. This may support the importance of structured feedback and repeated practice to facilitate simulator training and the acquisition of technical skills.

Furthermore, isolated part task simulator training may not be sufficient for learning the technical skills required for FOI. Unless complemented by effective clinical training, skills may not be successfully acquired.[19] Our cohort of RRTs only received simulator-based training, unlike novice anesthesiology trainees who receive a variable training mix of academic, clinical, and simulator teaching. A stronger correlation may have occurred if our RRTs had received this type of training.

Both simulators used in this study have been shown to lead to improved acquisition of FOI skills, when compared with traditional teaching. Our group previously demonstrated that a low fidelity box model led to better acquisition of the skills required for FOI than didactic teaching.[6] Goldmann and Rowe[5,7] showed that the virtual reality, computerized bronchoscopy simulator (Accutouch® endoscopy simulator, Immersion medical, Gaithersburg, MD, USA) successfully led to good acquisition of the technical and psychomotor skills required for FOI. It is unlikely that a lack of correlation between simulator and clinical performance results from failure of the simulators to train the skills required. However, there are several clinical factors which neither simulator can replicate, for example blood or mucus secretions. Currently, there are no FOI simulators which incorporate all the key constructs of a clinical performance in their design. Eventually, the technology may exist to better replicate an intraoperative experience and, thus, demonstrate a better correlation between time to complete a simulated FOI and actual clinical performance.

Studies involving simulation for the training of technical skills and assessment of new airway tools are becoming increasingly prevalent.[20] The question is often asked whether simulator data can be extrapolated to real patients and, indeed, this is often assumed. A "short" simulator time is occasionally used to support a claim of increased clinical efficacy. In light of this study, other measures of technical skill in the simulator, such as GRS and checklists, might be more appropriate. In a surgical study, Datta *et al.*[9] compared bench model GRS and checklist scores with clinical GRS and checklist scores for performance of saphenofemoral dissection, and found a strong correlation between the part-task simulator and clinical scores. It would be valuable to confirm if this holds true for technical skills in anesthesiology. Using a GRS and checklists to assess simulator performance may be a better way of predicting clinical performance. This has important implications when using simulators as assessment tools. GRS and checklists use a broader, multimodal approach to assess technical skill, whereas time only measures one variable of a complex, practical skill.

Interestingly, although simulator task time did not correlate with objective measures of clinical skill, we found that patient FOM time (lips to carina) correlated strongly with clinical skill, as measured by GRS and checklist. This suggests that time measured clinically may be a good surrogate measure when a GRS and checklist are not readily available. Further research is warranted to compare procedure performance time with proven objective measures of performance, namely the GRS and checklist, to determine if it is a useful surrogate for other skills in anesthesia.

The use of RRTs as subjects may limit the clinical applicability of this study. We chose not to utilize junior anesthesiology residents because a significant number of our PGY1 and 2 residents had experience of two or more FOI. We also had reservations about placing junior residents in positions where they may have thought that they were being assessed by staff anesthesiologists responsible for their academic evaluations. Although we considered tracheal intubation to be a separate skill set from FOM, it may have been reasonable to assess both manipulation and tracheal intubation together. Fundamentally, what anesthesiologists want to know is whether simulator training facilitates clinical FOI, not bronchoscopy skill.

Those using simulators to train novices in FOM skills should recognize that assessments based upon procedural performance time should not be related to clinical proficiency. More accurate objective measures of technical skill should be identified. The implications for simulator-based training may be an increased use of checklists and GRS, *in lieu* of reliance on "time to task completion" as a measure of clinical success.

Acknowledgement

We sincerely thank the Registered Respiratory Care Practitioners at St. Michael's Hospital who participated in this study.

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