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# Enhancing Laryngoscopy Mastery: The Impact of Autonomous Practice with Feedback-Providing Simulators

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## Abstract

Mastery learning with fixed end points and variable training time leads to more consistent expertise but is difficult to implement. Here we piloted mastery learning of laryngoscopy with independent practice. 35 learners participated in independent mastery learning on a manikin that provides automated performance feedback. A pre- and postpractice assessment of intubation skills was completed. After an average of 21 minutes of open practice, the percentage of subjects that met mastery criteria improved from 24% to 89% ($P < .05$). Independent intubation practice with manikin feedback facilitated mastery learning, enhanced procedural education, and may impact clinical care.

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The authors declare no conflicts of interest.

DISCLOSURES
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Endotracheal intubation (ETI) is performed >15 million times a year in the United States and comes with risk of adverse events, including aspiration, hypoxia, and dental injury which can cause patient harm and incur medico-legal liability.[1,2] Inexperienced providers are more likely to cause adverse events than experts who have performed many clinical ETI.[3] Experience gained through ETI simulation practice can improve a provider's proficiency and patient safety by providing simulated intubation experience before intubating patients.[3,4] Mastery learning is an optimized, evidence-based training method that included trainee real-time feedback and unlimited practice to achieve pre-set goals (mastery criteria). However, simulation practice typically occurs for a fixed duration because of logistical challenges in scheduling trainees, facilities, and faculty for open-ended training with no time limit.[5,6] As a solution, we tested a strategy involving independent simulation practice for a variable duration based on each trainee's pace and needs. It utilized a commercially available simulator that provided autonomous feedback on key ETI performance metrics for self-directed mastery learning.

## DESCRIPTION

### Structure of Open Practice Session

We implemented open practice sessions for a mixed group of 35 learners who were enrolled in an anesthesia rotation. Each session began with a short survey to assess prior intubation experience. Next, the baseline skill of each learner was assessed on an intubation manikin (BT Inc). This manikin can assess and display ETI metrics, including endotracheal versus esophageal tube placement, depth of tube placement, attempt duration, and magnitude of dental force on the upper incisors (Figure 1). However, the feedback display was hidden from the learner for the pretest and the learners received no external feedback about their technique or the test results. Learners intubated the manikin 3 times during the pretest using a Macintosh 3 Glidescope laryngoscope blade (Verathon Inc) by direct vision and without sight of the Glidescope screen. For each attempt, the facilitator recorded the maximum dental force, intubation time, endotracheal versus esophageal tube placement, and the Cormack-Lehane laryngeal view grade on the Glidescope screen.

After the pretest, each learner was given unrestricted time to practice intubation on only the BT manikin and work on an ETI mastery which was defined as the ability to achieve 3 consecutive successful ETI, completing each one within 60 seconds and with <10 N of dental force.[7] This goal was based on simulation-based metrics that have been shown in the literature to predict successful measured first-pass ETI in patients and could be surrogates for clinical expertise since first-pass success in ETI is a clinically relevant indicator of laryngoscopy expertise.[7]

The equipment for open practice was the same as in the pretest, but learners could look at the Glidescope screen and a tablet showing dental force and tube placement accuracy (Figure 2). Each subject was allowed to practice until they felt prepared to meet the mastery goal in a posttest. The posttest was identical to the pretest, 3 ETI on the manikin without Glidescope screen and feedback. A learner was marked as achieving mastery only if they met the criteria for all 3 attempts. After the posttest, the learners were asked to complete a survey evaluating their confidence in intubation before and after simulation training, the effectiveness of the manikin feedback, and the effectiveness of open practice on learning intubation using a 5-point Likert scale.

### Subject Demographics

A total of 35 participants were recruited and gave written informed consent. All of them completed the pretest, open practice, and posttest, but only 28 subjects filled out the postpractice survey. The learners consisted of 6 first-year critical care fellows, 14 anesthesia first-year residents, 4 first-year emergency medicine residents, and 11 third-year medical students with a spectrum of prior patient and manikin intubation experience. We excluded any critical care fellows who completed anesthesia residency and included learners who had <2 months of clinical anesthesia training as part of anesthesia residency, medical school rotations, and anesthesia electives done in other residency programs.

### Outcomes and Analysis

The outcomes of interest in the pretest and posttest were intubation time, maximum dental force applied, and first-pass success. The posttest survey assessed learner confidence in intubation before and after simulation training, the effectiveness of the manikin feedback, and the effectiveness of open practice on learning intubation using a 5-point Likert scale. We also ran paired *t* test for pre and postsession outcomes and Chi Square for binary variables, and created a regression model to predict if time practicing can predict mastery outcome. For all tests, we utilized a level of significance of 0.05.

### Session Feedback and Learner Assessment

The learners had a median experience of 10 prior patient intubations (range 0–100) and 5 prior manikin intubations (range 1–20). Only 24% of the learners had a baseline pretest performance that met the mastery criteria while 89% of the learners showed mastery in the posttest ($P < .05$; Figure 3A). The average time to intubate in the first pretest trial was 42.8 ± 27.0 seconds, which was significantly different than pretest trials 2 and 3, 28.0 ±17.9 seconds and 26.1 ± 22.2 seconds, respectively ($P < .05$). Although the intubation time decreased between trials in the pretest, there was no significant reduction in dental force or esophageal intubations. Violation of the 10 N limit on force on the upper incisors was the most common reason subjects did not achieve mastery in the pretest.

There were significant improvements recorded in the posttest time to intubate, avoidance of dental force, and ETI accuracy (Figure 3C). The learners spent an average of 20.6 ± 11.1 minutes during open practice and a regression model shows time spent practicing did not predict mastery outcomes ($R^2 = 0.033$). The duration of open practice did not show any statistically significant correlation with improvement in dental force, or intubation times from pretest to posttest.

The learners' average confidence on a 5-point scale changed from 3. 1 ± 1.3 to 3. 8 ± 0.77 ($P < .05$; Figure 3B). When we asked the learners to evaluate the open practice session on the Likert scale, 75% reported it being extremely or very useful compared to prior traditional intubation training sessions they have had. In addition, 79% of the learners reported that the dental force feedback provided by the manikin during open practice was very useful or extremely useful.

## DISCUSSION

In this study, we demonstrate a novel approach to training with manikin-provided feedback that allows trainees to achieve mastery performance criteria for ETI on a manikin without expert supervision. An important component of mastery learning is allowing for sufficient time to achieve the fixed mastery criteria, a factor that may vary between learners. In this study, trainee practice times ranged from 5 to 59 minutes. Despite the large range, we saw no correlation between practice time and performance on posttest. This is consistent with a mastery learning model where different learners require different durations of practice to reach the same level of skill mastery. Furthermore, we explicitly defined and informed the learners of mastery goals that they can work towards which likely contributed to them achieving mastery in a self-guided setting.[8]

Prior studies of simulation-based mastery learning for pediatric intubation, central venous catheterization, and lumbar puncture suggest that mastery learning leads to improved clinical performance compared to traditional.[9–11] Despite the described benefits, scheduling and cost may impede the more widespread use of simulation training with mastery learning end points. A variable practice duration model increases the time commitment of the faculty facilitators needed to provide feedback, thus increasing the cost.[12,13] At our institution the cost of independent training with automated performance feedback is estimated to be an initial $5000 for the manikin plus $75/h for facility and equipment charges versus $375/h with faculty time as a cost. By replacing faculty supervision with simulator feedback, simulation training for mastery learning of procedural skills becomes more cost-effective, less resource intensive, and as a result more likely for widespread acceptance in medical education curricula. However, it is important to keep in mind without a randomized controlled trial, we cannot assess the importance of qualitative feedback provided by faculty supervision in comparison to objective metrics used here.

We demonstrate learners can achieve procedural mastery with simulation training involving independent practice with a feedback-providing manikin. Our self-directed approach reduces the need for continuous faculty supervision by utilizing manikin-provided feedback and addresses some of the financial and logistical challenges inherent in traditional procedural training. Prior studies have shown success rates in clinical practice after simulation training in ETI that are equivalent or superior to traditional clinical training.[14] Further study is needed to correlate the improvement seen for ETI performance in a simulated setting with better ETI success in patients.

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## REFERENCES


1. Turner JS, Bucca AW, Propst SL, et al. Association of checklist use in endotracheal intubation with clinically important outcomes: a systematic review and meta-analysis. JAMA Netw Open. 2020;3:e209278. [PubMed: 32614424]
2. Cook TM, MacDougall-Davis SR. Complications and failure of airway management. Br J Anaesth. 2012;109(suppl_1):i68–i85. [PubMed: 23242753]
3. Castanelli DJ. The rise of simulation in technical skills teaching and the implications for training novices in anaesthesia. Anaesth Intensive Care. 2009;37:903–910. [PubMed: 20014595]
4. Komasawa N, Berg BW. Simulation-based airway management training for anesthesiologists: a brief review of its essential role in skills training for clinical competency. J Educ Perioper Med JEPM. 2017;19:E612. [PubMed: 29766036]
5. Cho KK, Marjadi B, Langendyk V, Hu W. The self-regulated learning of medical students in the clinical environment: a scoping review. BMC Med Educ. 2017;17:112. [PubMed: 28693468]
6. Gent D, Kainth R. Simulation-based procedure training (SBPT) in rarely performed procedures: a blueprint for theory-informed design considerations. Adv Simul (London, England). 2022;7:13.
7. Hastings RH, Tapia VJ, Lurie B, et al. Predicting trainee clinical success from performance at simulated endotracheal intubation. Simul Healthc J Soc Simul Healthc. 2020;16:e123–e128.
8. Chatterjee D, Corral J. How to write well-defined learning objectives. J Educ Perioperat Med. 2017;19:E610.
9. Barsuk JH, McGaghie WC, Cohen ER, Balachandran JS, Wayne DB. Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. J Hosp Med. 2009;4:397–403. [PubMed: 19753568]
10. Barsuk JH, Cohen ER, Caprio T, McGaghie WC, Simuni T, Wayne DB. Simulation-based education with mastery learning improves residents' lumbar puncture skills. Neurology. 2012;79:132–137. [PubMed: 22675080]
11. Thomaz Bittencourt C, Amélia G, Reis Sylvia CL, et al. Changing the view: impact of simulation-based mastery learning in pediatric tracheal intubation with videolaryngoscopy. J Pediatr. 2021;97:30–36.
12. Tolsgaard MG, Tabor A, Madsen ME, et al. Linking quality of care and training costs: cost-effectiveness in health professions education. Med Educ. 2015;49:1263–1271. [PubMed: 26611191]
13. Rees CE, Foo J, Nguyen VNB, et al. Unpacking economic programme theory for supervision training: preliminary steps towards realist economic evaluation. Med Educ. 2022;56:407–417. [PubMed: 34817093]
14. Goldberg A, Silverman E, Samuelson S, et al. Learning through simulated independent practice leads to better future performance in a simulated crisis than learning through simulated supervised practice. Br J Anaesth. 2015;114:794–800. [PubMed: 25571933]

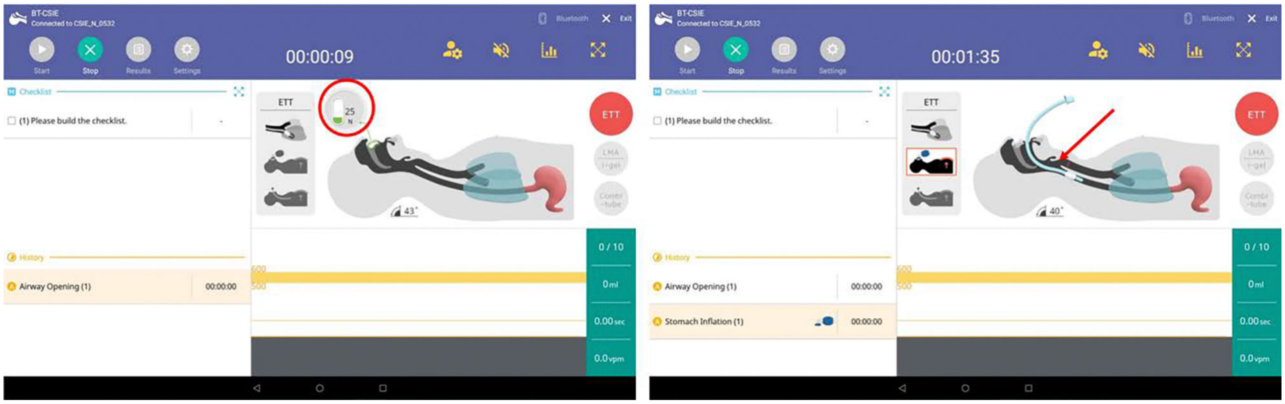


**Figure 1.**

Screenshot of the BT Inc Software showing manikin feedback as seen by the learner. Left, Screenshot of the real-time manikin feedback showing 25 N of force being applied on the upper incisors (red circle). Right, Screenshot of the real-time manikin feedback showing tube placement in the esophagus (red arrow). More information about the manikin can be found here: https://btincusa.com/product/airway-management-simulator/.

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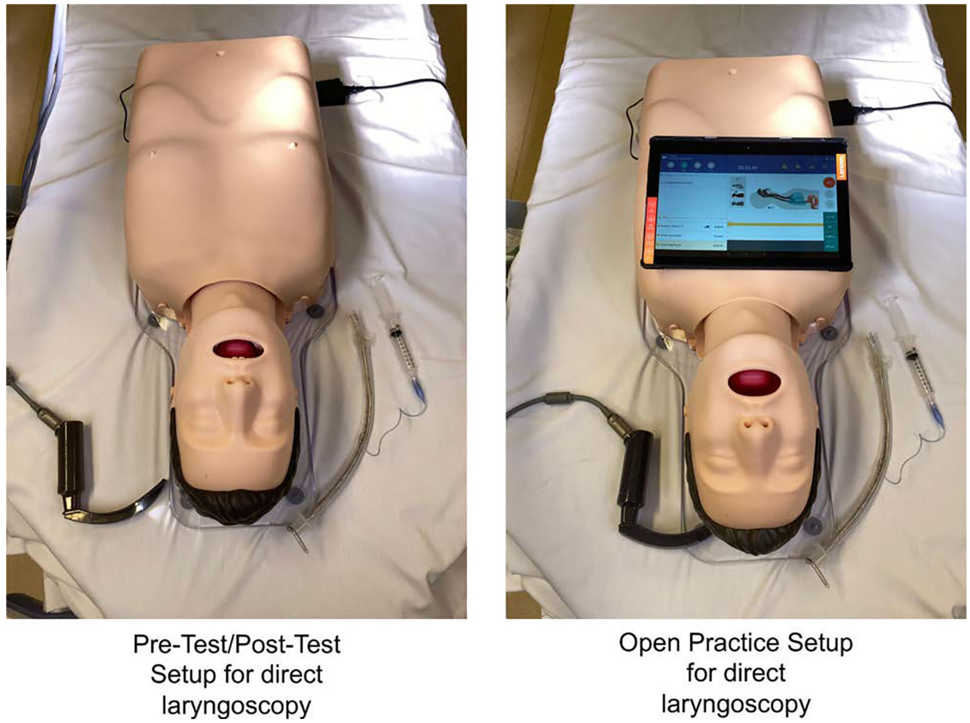


**Figure 2.**

Setup for testing and practice with the study group, showing the setup utilized for the pretest and posttest where the Glidescope video was only available to the study facilitator for data collection. Open practice setups are shown with the manikin feedback.

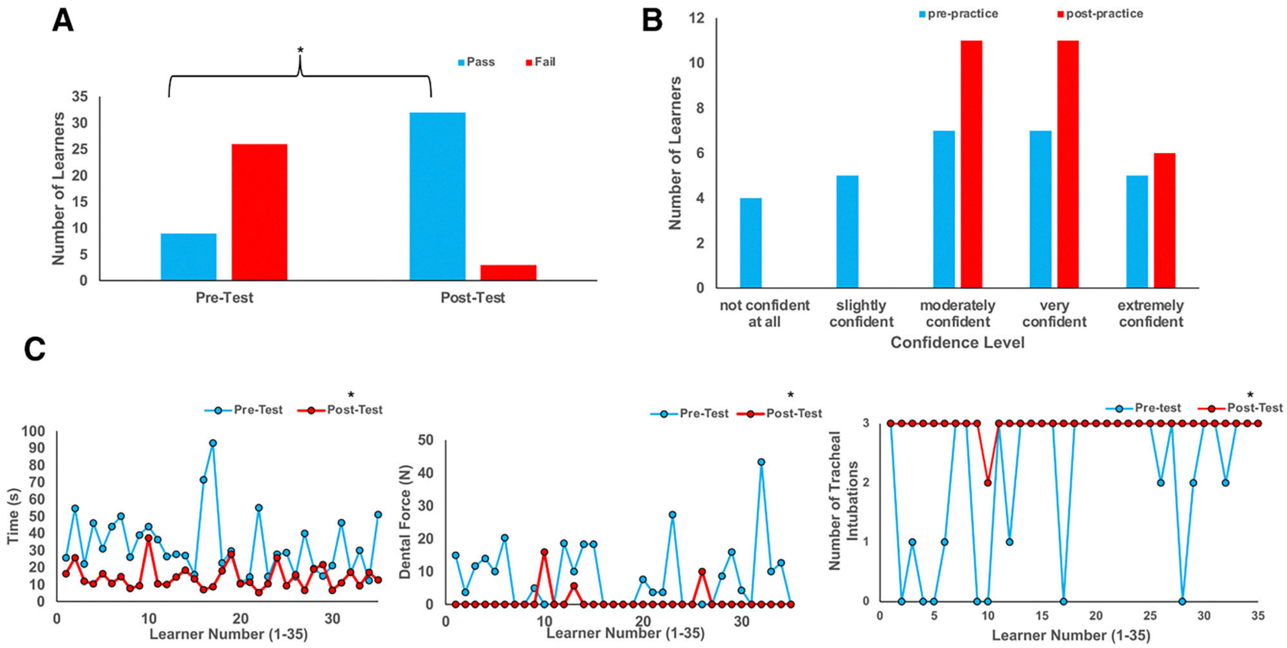


**Figure 3.**

Figure 1 pretest to posttest changes in learner performance. A, Bar graph showing statistically significant difference between the proportion of learners that achieved mastery in pretest and posttest. B, Survey results on confidence before and after open practice showing a statistically significant improvement in confidence. C, Scatter plots showing pretest and posttest average intubation times across 3 trials for each learner and average dental force across 3 trials for each learner.*Indicates statistical significance of $P < .05$.