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Comparison of a Ferret Model with an Inanimate Simulator for Training Novices in Techniques for Intubating Neonates

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Simulators for neonatal intubation training have improved, prompting us to compare a state-of-the-art simulator with live ferrets for training novice family-medicine residents in this crucial skill. After a scripted didactic presentation, we used a crossover study design and randomly assigned residents to receive simulator or live ferret training, after which they repeated the procedure by using the opposite method. Participants were asked to report their level of confidence and competence before and after each training session and the usefulness of each training method. In addition, residents were videotaped performing the procedure and evaluated by using a modified global rating scale. The 2 methods did not differ in regard to self-reported confidence, competence, or usefulness of each training procedure. A majority of participants indicated that they preferred using the ferrets over the simulator, with realism cited most frequently as the reason for their choice. Videotape scores for time and motion and flow of the procedure were higher when the simulator was used, but higher for instrument handling when ferrets were intubated. Overall scores were higher for videotaped evaluations with the simulator compared with the ferrets. According to these findings, the simulator appears to provide adequate instruction for the initial training of novice learners in neonatal intubation techniques.

Unquestionably, neonatal intubation is a high-stakes procedure that is performed under stressful, highly emotional circumstances. Rates for successful neonatal intubations by medical residents are low, varying from 20% to 69% depending on location and experience. For example, in 2003, one group reported successful intubation rates of 50% to 62% for pediatric house officers, with 35% never being successful, and none being able to consistently intubate a neonate on the first or second attempt more than 80% of the time over a 2-y period.[10] Similar findings were described in 2005[18] and 2006[21] by other groups. The situation has not improved over time, according to more recent reports.[2,7,14,24] This inability to successfully complete neonatal intubations among medical residents may be attributable to mandated decreases in work hours for medical trainees, resulting in fewer opportunities to perform the procedure,[13] and to a recommendation against the routine use of endotracheal intubation in vigorous term meconium-stained babies, resulting in fewer neonates needing the procedure.[9]

Opportunities for medical residents to perform intubations on newborns are inadequate to develop proficiency in the skill.[18] Live animal models, specifically kittens[16] and ferrets,[17,22] have been successfully used for neonatal intubation training in the past. However, the use of kittens has been criticized as not being anatomically representative,[27] and as kittens grow into adults, their anatomy becomes too large to simulate neonatal humans.[17] The ferret larynx, in contrast, is similar in size and appearance to a human newborn's and has proven to be a successful training model with minimal trauma to the ferrets.[17]

Previously, neonatal intubation simulators have not proven effective for training residents to a level of competency. Various reasons have been advanced for this deficiency, including the want of fidelity and realistic anatomy in task trainers; absence of secretions, airway edema, and tissue movement; and lack of time pressure and anxiety.[2,11] However, simulators have been improving over time. Mindful of the need to replace live-animal use whenever possible (the 3Rs principle of replacement), we compared the acquisition of basic neonatal intubation skills by novice family-medicine residents using the current state-of-the-art neonatal intubation simulator and live ferrets. To this end, we used a crossover design in which subjective measures obtained from participants and objective data obtained from videotape of the procedures were compared.

Materials and Methods

Animals. Castrated male ferrets ($n = 6$; weight 0.9 to 1.25 kg) were purchased from Marshall Farms (North Rose, NY). On receipt, they were individually microchipped (Avid, Norco, CA) and quarantined for 30 d prior to being introduced into the ferret colony. Ferrets were group-housed in a large primate cage (Britz, Wheatland, WY) that included seclusion boxes, ramps, and hammocks and were allowed to play in a custom playroom multiple times each week. PVC pipe, a hammock, a swine scratch pad (Bio-Serv, Frenchtown, NJ), shallow water bath, and various cat and ferret toys were provided in the playroom. The ferrets received positive human interaction on a daily basis through gentle handling, grooming, and offering food treats.

The ferrets were housed on a 12:12-h light:dark cycle in an animal room maintained at 19 to 20 °C with a relative humidity of 30% to 70% and 10 air changes hourly. The ferrets were fed (Global Ferret Diet, Harlan Teklad, Madison, WI) and provided water via water bottles free choice. Small amounts of high-calorie nutritional supplement (Nutrical Oral Gel, Vetoquino, Fort Worth, TX) and cat or ferret treats were provided periodically. Health and welfare checks were provided by animal care staff twice daily, and each ferret received an annual physical consisting of a thorough examination, electrocardiogram, dental

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prophylaxis, vaccinations for rabies and canine distemper, fecal exam, and CBC analysis with basic metabolic profile.

The use of ferrets in our training program was conducted under a restricted-species permit issued by the California Department of Fish and Game in compliance with the Animal Welfare Act as well as other federal and state regulations and adhered to the *Guide for the Care and Use of Laboratory Animals*.[15] The care and use of ferrets for neonatal intubation training was approved and overseen by our IACUC and conducted in our AAALAC-accredited facility.

Prior to each neonatal intubation session, ferrets were weighed and given a health examination by the attending veterinarian. Preanesthetic medication consisted of atropine sulfate (0.04 mg/kg SC, 25-gauge needle), followed in 10 min by a combination of xylazine (2 mg/kg IM), ketamine (30 mg/kg IM), and acepromazine (0.1 mg/kg IM) by means of a 25-gauge needle. Ophthalmic ointment was applied to the eyes once sedation was achieved. The ferrets also received meloxicam (0.2 mg/kg SC, 25-gauge needle), a NSAID. The ferrets were placed in dorsal recumbency and vital signs were continuously monitored by veterinary staff throughout the procedure, which generally lasted less than 30 min. Intubations were performed with 2.5- or 3-mm endotracheal tube facilitated by the use of a laryngoscope with a size 0 blade. Students generally, but not always, used a rubber-coated stylet in the lumen of the endotracheal tube. Intubation success was assessed directly by a faculty member who was experienced with ferret intubation and by the use of an end-tidal CO_2 detector (Nellcor Pediatric Colorimetric CO_2 Detector, Covidien, Mansfield, MA). Each ferret underwent a maximum of 5 intubations each session, which were held no more often than once each month. Instructors, the attending veterinarian, or veterinary technicians removed animals from training sessions when signs of trauma are observed (for example, swollen, red epiglottis or pharynx; blood on the end of the endotracheal tube), but this was extremely rare (perhaps 3 or 4 incidents in 7 y of training).

At the end of each session, each ferret was given a final physical exam, with particular attention paid to identifying any laryngeal trauma. Yohimbine (0.5 mg/kg SC, 25-gauge needle) then was given to counter the cardiac effects of xylazine, and the ferrets were allowed to recover in a veterinary intensive care unit (Plas-Labs, Lansing, MI) with oxygen, temperature, and humidity supported. Once alert, the ferrets were returned to their usual housing. All ferrets were eventually retired from training use because of age or unrelated health problems but remained in the colony because of restrictions placed on adoption by the State of California restricted-species permit.

Humans. Our institutional review board approved this study as an exempt protocol because no personally identifiable information was obtained and facial features were not captured on videotape. However, the voluntary, fully informed consent of the subjects used in this research was obtained. Novice family-medicine residents (n = 57) were recruited to participate in the neonatal intubation training.

Study design. Prior to beginning training, participants received a scripted presentation on the indications and correct procedures for neonatal intubation, ferret anatomy, the personal protective measures required for training sessions, and the ethical treatment of animals. The participants then completed a survey that assessed their confidence in their ability to successfully intubate a neonate (Likert scale; 0 [not comfortable] to 5 [very comfortable]) and how competent they believed they were to successfully intubate a neonate (Likert scale; 0 [not competent] to 5 [very competent]). Participants then were randomly assigned to begin training with either a simulator (SimNewB, Laerdal Medical Group, Waggingers Falls, NY) or live ferrets. Participants were identified by number and carefully videotaped to include only images of the simulator or ferret and the participant's hands. After completing the procedure, the trainees were asked the same questions about their confidence and feelings of competence; they also were asked how useful they found the training (Likert scale, 0 [not useful] to 5 [very useful]). They then completed a second training session using the opposite modality, in a crossover study design. Finally, students were asked which method they preferred—simulator or live animal—and the reasons for their preference. Videotapes were reviewed later by a board-certified pediatrics faculty member who did not take part in the training sessions. Each participant was scored by using a modified global rating scale[19] on: time and motion (1 [many unnecessary moves] to 5 [economy of movement and maximal efficiency]); instrument handling (1 [repeatedly makes tentative and awkward moves] to 5 [fluid movements with instruments, no awkwardness]); flow of operation and forward planning (1 [frequently stopped or needed to discuss next move] to 5 [obviously planned course with effortless flow]); knowledge of instruments (1 [frequently used an inappropriate instrument] to 5 [obviously familiar with the instruments required]); and overall rating (1 [overall does not meet expectations] to 5 [superior, exceeds expectations]). This modified global rating scale has been used successfully to evaluate technical skills among surgeons as well as the success of teaching other invasive procedures.[19]

Analysis. Survey results and videotape scores were collated and prepared for analysis using standard statistical software (STATA version 12.0, Stata Corporation, Bryan, TX). Data were summarized as the mean and SEM for each question or score. Because a crossover study design was used, a crucial question was whether the order in which subjects performed training influenced the outcomes.[1] Simple t tests were used first to compare results for each endpoint by training method to determine whether the order in which training was performed influenced the results. When training order did not affect the outcome, the results were aggregated to compare training methods. Otherwise, when training order had a significant effect, ANOVA was used to analyze results accounting for the influence of training order. Chi-squared tests were used to analyze the reasons for training preference. Statistical significance was defined as a P value of less than or equal to 0.05.

Results

A total of 57 participants completed both arms of the study. Prior to beginning training, participants reported that their confidence and competence to perform neonatal intubation was slightly below the midpoint—both 2.3 on a 5-point Likert scale. Training order did not affect self-reported scores regarding confidence, competence, and usefulness of training (Table 1), thus allowing a pooled comparison of these scores (Table 2), in which no significant differences were seen in scores reported for ferret or simulator training. After simulator or live ferret training, scores for confidence, competence, and usefulness improved significantly ($P < 0.01$ in each case) compared with pretraining values (Table 2), although the improvements were modest.

Ratings for videotaped procedures are shown in Table 3. In this case, the training order significantly influenced instrument handling and knowledge scores for ferret training, with higher scores when the simulator was the first arm of the crossover study ($P = 0.005$ and $P = 0.004$, respectively). The opposite trend was seen for time and motion and flow scores, although these results were not statistically significant. Therefore, we elected

Table 1. Comparison of survey scores for ferret compared with simulator according to training order

	Training order			
	Ferret–simulator		Simulator–ferret	
Confidence	Ferret	2.9 ± 0.2	Ferret	3.0 ± 0.2
	Simulator	3.2 ± 0.2	Simulator	2.9 ± 0.2
Competance	Ferret	2.8 ± 0.3	Ferret	3.1 ± 0.2
	Simulator	3.1 ± 0.2	Simulator	3.0 ± 0.2
Usefulness	Ferret	4.1 ± 0.3	Ferret	3.8 ± 0.2
	Simulator	4.0 ± 0.2	Simulator	3.7 ± 0.2

Data are given as mean ± SEM.

Table 2. Pooled comparison of survey scores for ferret compared with simulator training

	Ferret	Simulator
Confidence	2.9 ± 0.2[a]	3.0 ± 0.1[a]
Competance	3.0 ± 0.2[a]	3.1 ± 0.1[a]
Usefulness	4.0 ± 0.2	3.8 ± 0.2

Data are given as mean ± SEM.
[a]Value is significantly ($P < 0.05$) increased from pretraining score (2.3 for both parameters).

to use ANOVA for comparing videotape scores between ferret and simulator training to account for the influence of training order (Table 4). Participants had significantly higher time and motion and flow scores when training with the simulator ($P < 0.01$ in each case), whereas instrument handling scores were significantly higher with ferrets ($P = 0.04$); knowledge scores did not differ between the 2 training groups ($P = 0.24$). Globally, participants scored significantly ($P < 0.01$) higher when training with the simulator than with the ferrets.

After completing the training, 83% ($n = 54$ responding) of participants indicated they preferred the ferret over the simulator. Reasons given included realism (93% for ferrets compared with 33% for simulator, $P < 0.01$), better learning experience (33% for ferrets compared with 33% for simulator, $P = 1.00$), being less intense (7% for ferrets compared with 22% for simulator, $P = 0.14$), and anatomy (33% for ferrets compared with 11% for simulator, $P = 0.09$). Regarding anatomy, 9% of trainees indicated that the simulator was too stiff and difficult to manipulate.

Discussion

Intubation simulators have become increasingly sophisticated, prompting us to wonder whether current state-of-the-art devices would offer a training opportunity equal to or better than animal models for teaching neonatal intubation. Residents evaluated in this training event had novice skill levels, with only 13% reporting any experience intubating a neonate within the past 12 mo. The residents' self-assessed confidence and belief in their competence to perform neonatal intubation improved significantly compared with baseline, and their feelings about the usefulness of each method indicated no significant differences between live ferrets and the simulator that we used. In light of previous research, many more training events likely would be required to increase residents' self-assessed competence and confidence in neonatal intubation, and a difference between the self-reported usefulness of the training methods might emerge with additional training events.

Objective measures taken from videotaped procedures showed that, in regard to time and motion and flow of the procedure, the residents performed significantly better when using the simulator than ferrets. This difference may be attributed to their reluctance to potentially harm the animal and their willingness to more quickly and unhesitatingly perform the procedure on a plastic model. In contrast, this finding may also be attributable to their familiarity with the human form as compared with the ferret. However, the residents had better instrument handling when intubating ferrets. This finding surprised our experienced faculty, given that we consider the procedure in animals to be more difficult due to the need to maneuver around teeth and to deal with secretions that are not present in the simulator. The faculty observer who scored this portion of the study was interviewed after data collection was complete and revealed that the lower scores given for instrument handling with the simulator were primarily due to forceful movement of the laryngoscope blade that was judged to be "definitely harmful" if done on a neonate. Residents may be more forceful with handling the laryngoscope due to the stiffness of the mannequin airway. Conversely, we have noticed a tendency among the residents to be very gentle when handling the ferrets, out of a desire to do no harm. We consider this experience to be good preparation for intubating live neonates. That knowledge scores were equal for residents using the simulator and ferrets was expected, given that this component was based largely on the information gained during didactic sessions that preceded the actual training. The overall rating was significantly higher when participants were intubating the simulator compared with ferrets and was equivalent to "meets expectations but needs improvement" on a Likert scale. This outcome may reflect the relative ease of intubating the simulator compared with the ferret, and this finding should be correlated to actual competence in future studies. In addition, participants overwhelmingly preferred the ferrets over the simulator, citing realism as the primary factor. Interestingly, anatomy was mentioned more often by trainees who preferred ferrets, although the difference was not statistically significant.

This study used a crossover design, which allowed us to make within-subject rather than between-subject comparisons, substantially decreasing variability and improving precision.[1] A concern with this approach is that there may be a carry-over from one phase to the next, so we chose to examine the data for the influence of treatment order and to adjust for that effect when necessary. Any experimental study needs to minimize the influences of selection and information bias, which may distort the relationship between the treatment and the outcome. We carefully randomized the assignment of study participants to prevent selection bias, but we found dealing with information bias to be difficult. All identifying features were removed from study-related materials to blind the investigators and to protect the privacy of the participants, but it was impossible to blind the videotape evaluator to whether training was being conducted with the simulator or the ferret. However, the videotape evaluator was an experienced faculty member who was strongly in favor of using ferrets for neonatal intubation training. The fact that residents scored significantly higher in the overall modified global rating score when using the simulator leads us to believe the knowledge of the particular method in use did not influence the rating decisions. Finally, this study would have greatly benefited from evaluating residents trained on a simulator or ferrets against a 'gold standard'—in this case, live neonates or cadavers—but doing so was logistically impossible.

Traditionally, training for invasive procedures among residents in graduate medical education consists of didactic

Table 3. Comparison of videotape scores for ferret compared with simulator according to training order.

	Training order			
	Ferret–simulator		Simulator–ferret	
Time and motion	Ferret	2.7 ± 0.2	Ferret	2.6 ± 0.2
	Simulator	3.1 ± 0.2	Simulator	3.5 ± 0.2
Instrument handling	Ferret	2.8 ± 0.2	Ferret	3.5 ± 0.2[a]
	Simulator	3.1 ± 0.2	Simulator	2.6 ± 0.2
Flow	Ferret	2.8 ± 0.2	Ferret	2.9 ± 0.2
	Simulator	3.3 ± 0.2	Simulator	3.7 ± 0.1
Knowledge	Ferret	3.1 ± 0.2	Ferret	3.7 ± 0.1[a]
	Simulator	3.4 ± 0.2	Simulator	3.1 ± 0.1
Overall	Ferret	2.7 ± 0.2	Ferret	2.7 ± 0.2
	Simulator	3.3 ± 0.2	Simulator	3.5 ± 0.1

Data are given as mean ± SEM.
[a]Value is significantly ($P < 0.05$) different from that for the other method at the same time point.

Table 4. Adjusted comparison of videotape scores for ferret compared with simulator training

	Ferret	Simulator
Time and motion	2.5 ± 0.1	3.2 ± 0.1[a]
Instrument handling	3.1 ± 0.2	2.7 ± 0.1[a]
Flow	2.8 ± 0.1	3.5 ± 0.1[a]
Knowledge	3.3 ± 0.1	3.2 ± 0.1
Overall	2.6 ± 0.2	3.4 ± 0.1[a]

Data are given as mean ± SEM.
[a]Value is significantly ($P < 0.05$) different between methods.

instruction, followed by supervised performance on a patient who requires the procedure.[20] However, work-hour limitations may limit the opportunities residents have to perform these procedures.[13] At the same time, there is increasing pressure on the directors of residency programs to minimize resident procedural training using patients; the opinion is increasing that patients should receive care from the most experienced provider available, particularly for sensitive emergency procedures, such as intubating a neonate.[5] Live animal laboratories where residents perform procedures under the direct supervision of a faculty member have offered a validated approach for endotracheal intubation.[12,17,22] Simulation offers an alternative method and has proven to be effective for intubation training in some venues.[3-5] However, educators have voiced concerns about the fidelity of simulators—whether the materials and anatomic design of the devices provide sufficient realism. One group compared computed tomography scans of adult trauma patients with those of 4 high-fidelity patient simulators and 2 airway trainers and found that the simulators and trainers did not accurately model the patients' anatomy.[25] In our case, the SimNewB lacks any laryngeal anatomy, a deficiency that we consider to be substantial.

Some have suggested that simulator use decreases stress levels, resulting in incomplete transfer of skills to the clinical arena.[11,23] We were not surprised that fewer of the residents who preferred the ferret model reported that it was the less intense of the 2 methods than did those who preferred the simulator, although this difference was not statistically significant. Unfortunately literature that compares the 2 approaches for teaching intubation is scant, although one group has highlighted the benefits and drawbacks of each method.[26] The current study is the first that we know of that provides objective evidence that residents performed better during training with the SimNewB neonatal intubation simulator, although a significant proportion preferred training with ferrets. Even after training, the novice residents we trained did not achieve procedural competence, underscoring the fact that continued practice is needed to develop this skill, and 100 intubation attempts has been recommended as being necessary to achieve maximal proficiency.[6] Such practice is effective regardless of whether it occurs weekly or on consecutive days.[8]

It might be tempting to extend the findings from our investigation to other procedures that are commonly taught to medical residents by using live animal laboratories and to advocate replacing those sessions with simulation as well. However, we argue that each procedure and training method must be evaluated objectively. Clearly, simulators will continue to become more sophisticated and will increase in realism and fidelity. As these improved models become available, they should be used to replace live animal use when objective data indicate they are as good or better.

Our current study provides important evidence that novice students can adequately learn neonatal intubation skills on a state-of-the-art mannequin, such as the SimNewB. Our findings also support the need for continued development of simulators that imitate the tissue and anatomic landmarks of neonates more accurately to ensure sufficient realism in training.

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Laboratory Animals (National Research Council). The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and Air Force Instruction 40-402, *Protection of Human Subjects in Biomedical and Behavioral Research*.

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