Creation of an Educational Anatomical Bronchoscopy Model

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Key Words: *anatomical model, fibrobronchoscopy, skills, simulators.*

Summary. *The aim was to make an anatomical model of a tracheobronchial tree and investigate its suitability for fiber optic bronchoscopy training.*

Methods. The model was made using the papier-mâché technique. Photos of the trachea, the carina and the right bronchus were made during the fiber optic bronchoscopy procedure and put next to real human photos. Medical students (n=54) performed fiber optic bronchoscopy on our model and on the commercial trainer after the lecture. They and 8 certified anaesthesiology experts took the semi-structured interview about the students' made model. Differences in the duration of fiber optic bronchoscopy on both trainers were measured by the Wilcoxon signed ranks test at P<0.05.

Results. All the experts and 91% of the students confirmed that bronchoscopic images of our model were similar to human. Everyone agreed that our model was useful for learning and was worth the time spent producing it, and 37.5% of the experts and 58.5% of the students stated that it was suitable for training and gaining motor skills. Besides, 12.5% of the experts and 24.5% of the students emphasised low production costs of this model. Meanwhile, 12.5% of the experts and 26.4% of the students noted its temporality and fast obsolescence after many bronchoscopy tests. Besides, 24.5% of the experts and 35.8% of the students argued that white colour, texture and absence of tracheal rings in our model reduced similarity to real anatomy. However, there was no statistically significant difference between duration of bronchoscopy in both.

Conclusions. The designed fiber optic bronchoscopy model was anatomically correct and cheap. There was no statistically significant difference between the duration of bronchoscopy performance in the two models: the fiber optic bronchoscopy model designed for the purposes of the study and the commercial trainer.

Introduction

A fiber optic bronchoscope is a flexible optical device used for manipulation in the upper respiratory tract, trachea and bronchi. It is widely used in anaesthesiology and intensive therapy. When the advanced nursing programme was developed, nurses have been able to perform airway management, including intubation, under doctor's supervision. The main indications for using a fiber optic bronchoscope in anaesthesiology are tracheal intubation (an alternative for laryngoscopy), airway obstruction, cervical spine injury, one-lung ventilation and endotracheal tube replacement. Meanwhile, in intensive care a fibrobronchoscope can be used to treat pulmonary atelectasis (when traditional therapy is ineffective), for diagnosis and management of bleeding in the respiratory tract, or for removal of a foreign body in the airways (1).

Although bronchoscopy is a well-tolerated procedure, complications are possible. Complication rates range from 1.1% to 1.2%, while mortality rates range from 0% to 0.02%. The most common complications are hypoxemia, an increase in the arterial blood pressure, bleeding, arrhythmias (sinus tachycardia, sinus bradycardia, premature ventricular and atrial contractions) and infection. Pneumothorax is also possible (0.1%–0.16%) (1, 2).

To reduce the incidence of occurring complications, fibrobronchoscopy is performed by a qualified person. For this procedure, a good hand-eye coordination is very important, but it is acquired only with a lot of practice. Due to the lack of this psychomotor skill, most of the problems occur for doctors residents. Fibrobronchoscopy carried out by a completely inexperienced person is unethical and may be harmful to a patient (3). In this case, different commercial models for fibrobronchoscopy learning are very important. They offer a great opportunity for residents to gain a certain amount of knowledge and skills before the first contact with a patient. Residents can train for an unlimited number of times until they learn how to properly use a fibrobronchoscope.

Commercial models are convenient but expensive. Therefore, some authors try to produce cheap-

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er models, which could be used in hospitals with a limited budget (5). Some producers use a flexible hose which is bent to match bronchial tree anatomy (3). Others use a wooden board and attach 3 wooden plates with appropriate size holes through which they try to push a fibrobronchoscope (6). Instead of wooden plates, some producers use vinyl records with appropriate size holes, which are installed in a transparent box (7). These models are not only original, but also are no worse than commercial models for fibrobronchoscopy training.

The aim was to produce a life-size, anatomically correct tracheobronchial tree model and investigate its suitability for fibrobronchoscopy learning.

Material and Methods

The model was produced with reference to an atlas of anatomy and S. D. Domenico's article *Inexpensive anatomical trainer for bronchoscopy* (4, 8). Using 1.2 mm diameter steel wire, a tracheobronchial tree frame was formed and attached to a wooden board (Fig. 1). On the metal wire frame, modelling material – polymer clay – was applied, maintaining accurate dimensions of a tracheobronchial tree (Fig. 2). The resulting model was wrapped in food-wrapping film, so that adhesive paper could later be easily removed from the hard frame.

Next, the papier-mâché technique was applied: torn, small pieces of paper were soaked in glue and water solution and glued to the frame. After the frame was covered with one layer of scraps, it was left to dry and other layers were glued. In total, 7 layers were glued (Fig. 3).

Then, after cutting it into 8 parts, the paper was removed from the hard frame (Fig. 4). The inner surface of these parts was dyed with white paint, the parts were glued into a single model and a few more layers of glued scraps were added on top. When completely dry, the model was dyed with white paint (Fig. 5). The model production time was 11 hours (drying time excluded) (Fig. 6). The reality of the model was evaluated using a fibrobronchoscope, and bronchoscopic images were taken in 3 different areas (trachea, tracheal bifurcation and right bronchus), which were compared with the same areas of human bronchoscopic images (Fig. 7).

To evaluate the model suitability for learning, fibrobronchoscopy training was organised for students of the Lithuanian University of Health Sciences. First, a lecture on the fibrobronchoscopy application in clinical practice was held, after which

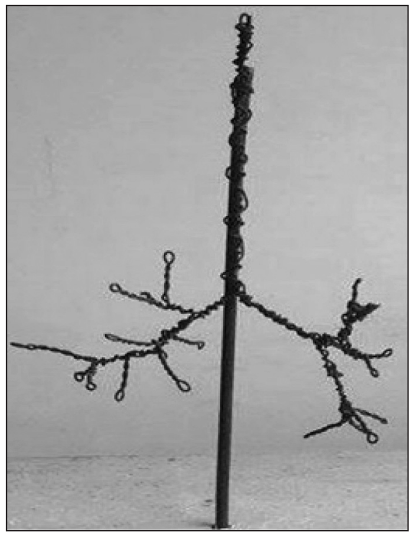

Fig. 1. The tracheobronchial tree frame from metal wire was formed

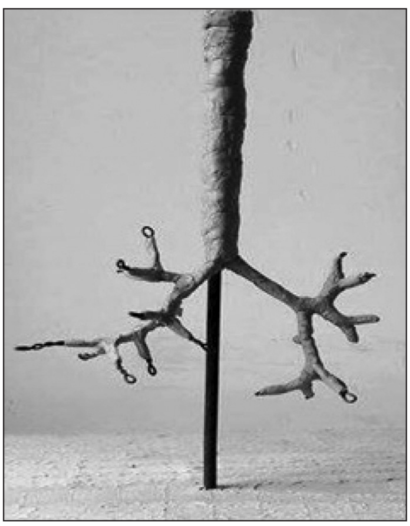

Fig. 2. The tracheobronchial tree frame was coated with polymer clay

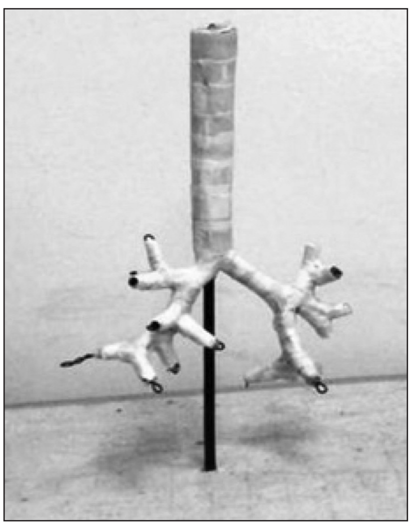

Fig. 3. The tracheobronchial tree frame was covered with scraps of paper

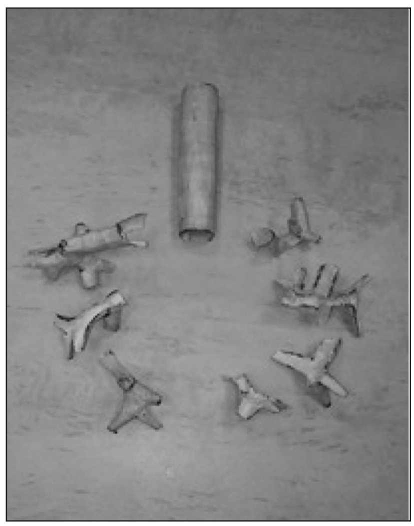

Fig. 4. Parts from the solid frame were cut and removed

Fig. 5. The model was glued and painted

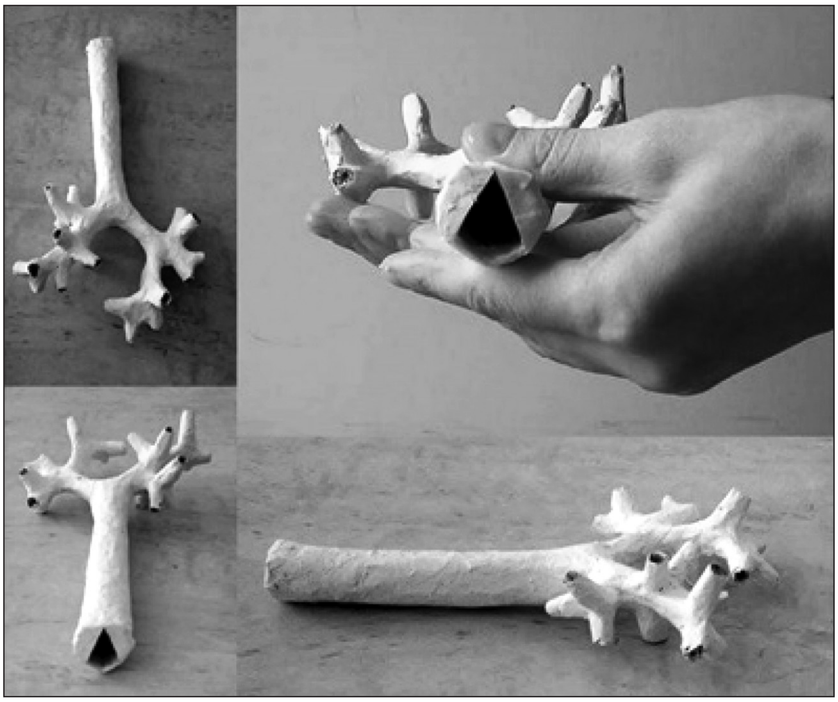

Fig. 6. The completed model

a test was provided. Students (n=54) who passed the test best learned to carry out bronchoscopy by themselves using the designed model and the commercial tracheobronchial tree model. During the training, each student's fibrobronchoscopy performance time was also evaluated (from the beginning until a fibrobronchoscope accessed the right main bronchus).

After the training, the students were given a questionnaire on the designed model and were asked to compare bronchoscopic images of the designed model and human bronchoscopic images (as completely similar, similar, not similar) and to report advantages, disadvantages and benefits of learning on the model. The questionnaire was also filled by 8 resuscitation specialists – doctors anaesthesiologists – who completed training held by the Committee for European Education in Anaesthesiology (CEEA) and had more than 3 years of experience performing bronchoscopy. Statistical analysis was performed and graphs were generated using IBM SPSS Statistics 20. Data are presented as absolute numbers, percentage, and mean and standard deviation. Differences between fiber optic bronchoscopy duration on both trainers were measured by the Wilcoxon signed ranks test at $P<0.05$.

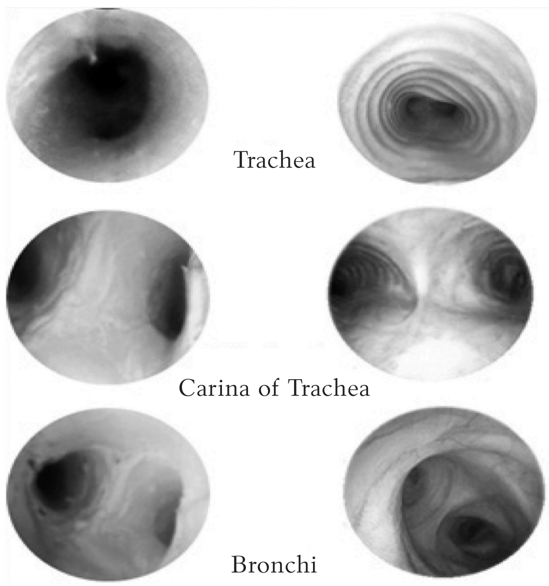

Fig. 7. Comparison of fibrobronchoscopic images of our model and the same areas of human bronchoscopic images

Results

When experts and students were asked to evaluate 3 bronchoscopic images, the absolute majority of 24 experts (100%) and 49 students (91%) answered that the designed model bronchoscopic images were similar or completely similar to human. All the experts and students agreed that our model was useful for learning fibrobronchoscopy and was worth the time spent producing it. One (12.5%) expert said that this model was more useful for those students who produced it. Three experts (37.5%) and 31 stu-

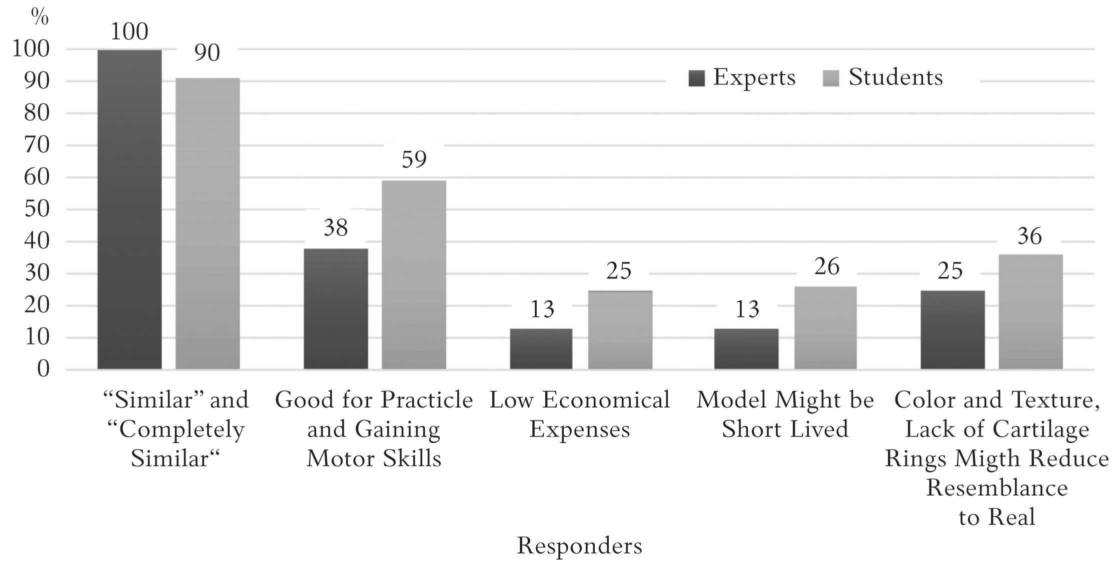

Fig. 8. Advantages and disadvantages of the model noticed by students and experts (percent)

dents (58.5%) stressed that one of the main advantages of the model was the ability for a student to train and gain motor skills due to an unlimited time and possibility to repeat the procedure until the desired result. One expert (12.5%) and 13 students (24.5%) emphasised low production costs of the model. When the subjects were asked to evaluate disadvantages of our model, 1 expert (12.5%) and 14 students (26.4%) noted its temporality and fast obsolescence after many bronchoscopy tests. Two experts (24.5%) and 19 students (35.8%) emphasised that white colour, texture, and absence of tracheal rings reduced its similarity to the real tracheobronchial tree anatomy. Besides, 1 expert (12.5%) indicated that the model would be more accurate if not only the trachea and bronchi but the upper respiratory tract was also included (Fig. 7).

The duration of bronchoscopy using the designed model was 7–384 s (average 51.5±62.98 s, median 27.0 s, mode 18.0 s). Four students (7.4%) did not finish the task. The duration of bronchoscopy using the commercial model was 7–176 s (average 50.1±30.01 s, median 44.0 s, mode 33.0 s). One student (1.9%) did not accomplish the task. There was no statistically significant difference between the duration in bronchoscopy performance in both models (P=0.322).

Discussion

Knowledge about bronchial tree anatomy and manual dexterity is essential in performing fibrobronchoscopy. All the equipment, its operating principles and fiber optic intubation stages should be well-known and clear to a doctor. Manipulations should be performed automatically, depending on the situation. However, this can be achieved only after extensive intubation training (9).

Inexperienced doctors benefit from bronchoscopy training when a variety of moulages are used. The advantage of such training is undeniable. Viren Naik and his colleagues proved it in their study. They evaluated two resident groups: one group listened to a detailed lecture on bronchoscopy and its application. Another group learned to use a fibrobronchoscope on their self-made model (the model group). Later, performance duration of fiber optic intubation of both groups was evaluated. The results indicated that performance duration of intubation was statistically significantly shorter in the model group (7).

Commercial models are realistic, good for learning, but their use is limited by cost. Therefore, some authors try to produce models which would be cheap (3–7). Our model price was under 10 euros. All experts and students agreed that our model was useful for learning fibrobronchoscopy and was worth the time spent producing it. For young professionals, such models are a great opportunity to acquire the necessary psychomotor skills, without harming the patient. Meanwhile, for experienced doctors, such models allow them not to lose their skills and continue to improve, especially in hospitals where the number of bronchoscopy performances is low.

Conclusions

Our model was anatomically correct and appropriate for fibrobronchoscopy learning. There was no statistically significant difference between the duration in bronchoscopy performance in both models. The most frequently noted advantages of our model were low production costs, the ability to train and acquire motor skills due to an unlimited time and possibility to repeat the procedure until the desired result.

The most frequently mentioned disadvantages of our model were temporality, the absence of tracheal rings, colour and texture dissimilarity in comparison with real tracheobronchial tree anatomy.

Statement of Conflict of Interest

The authors state no conflict of interest.

Mokomojo anatominio bronchoskopijų modelio kūrimas

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Raktažodžiai: anatominis modelis, fibrobronchoskopija, įgūdžiai, simuliatoriai.

Santrauka. *Tikslas* – pagaminti realaus dydžio, anatomiškai taisyklingą tracheobronchinio medžio modelį ir ištirti jo tinkamumą fibrobronchoskopijai mokytis.

Metodas. Modelis buvo gaminamas remiantis anatomijos atlasais ir S. D. Domenico straipsniu „Inexpensive anatomical trainer for bronchoscopy“ iš metalinės vielos, popieriaus ir klijų, taikant *papier-mâché* techniką. Fibrobronchoskopu buvo įvertintas modelio tikroviškumas ir nufotografuoti vaizdai iš trijų skirtingų sričių (trachėjos, trachėjos išsišakojimo vietos ir dešiniojo broncho), kurie lyginti su tų pačių sričių žmogaus bronchoskopijos vaizdais. Penkiasdešimt keturi medicinos studentai atliko fibrobronchoskopiją naudodami šio tyrimo metu sukurtą ir komercinį modelius. Vėliau šie studentai ir aštuoni gydytojai anesteziologai-reanimatologai užpildė anketą apie šio tyrimo metu sukurtą modelį. Taip pat buvo vertinama fibrobronchoskopijos atlikimo trukmė naudojant abu modelius.

Rezultatai. 100 proc. ekspertų ir 91 proc. studentų atsakė, kad šio tyrimo metu sukurto modelio bronchoskopiniai vaizdai yra „*panašūs*“ arba „*visiškai panašūs*“ į žmogaus. Visi sutiko, kad mūsų modelis yra naudingas fibrobronchoskopijai mokytis ir yra vertas praleisto laiko jį gaminant. 37,5 proc. ekspertų ir 58,5 proc. studentų teigė, kad mūsų modelis tinkamas treniruotis ir įgyti motorinių įgūdžių dėl neribojamo laiko. Be to, 12,5 proc. ekspertų ir 24,5 proc. studentų pabrėžė, kad modelio gamybos išlaidos nedidelės. 12,5 proc. ekspertų ir 26,4 proc. studentų taip pat pastebėjo, jog modelis neilgaamžis ir po daugelio bronchoskopijos testų greitai susidėvi. 24,5 proc. ekspertų ir 35,8 proc. studentų teigė, kad balta mūsų modelio spalva, tekstūra, trachėjos žiedų nebuvimas sumažina panašumą į tikrą tracheobronchinio medžio anatomiją. Tačiau statistiškai reikšmingo skirtumo tarp abiejų modelių bronchoskopijos trukmės nebuvo.

Išvados. Šio tyrimo metu pagamintas modelis buvo anatomiškai taisyklingas ir nebrangus. Statistiškai reikšmingo skirtumo tarp abiejų modelių bronchoskopijos trukmės nebuvo.

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