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TRACHEOLARYNGO-ESOPHAGEAL-CARDIOPULMONARY UNIT: A REUSABLE MODEL IN TEACHING-LEARNING ENDOTRACHEAL INTUBATION, BRONCHOSCOPE HANDLING, AND LUNG BIOPSY TRAINING

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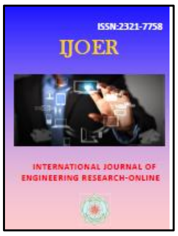

ABSTRACT

Endotracheal intubation, bronchoscope handling and biopsy training practices in medical education have an important impact on human and animal health as well as significant human and economic benefits. We present a low-cost and reusable tracheolaryngo-esophageal-cardiopulmonary unit and its skeleton frame which has been used as a biomaterial in teaching and learning programs of bronchoscope handling, endotracheal intubation and biopsy training. Cardiopulmonary blocks including the trachea, the esophagus, the larynx and the tongue were harvested from five dogs, preserved with McCormick's-glycerin-phenic acid solution, and stored at room temperature. Separately, the skeleton frame of one of the dogs was dissected and preserved using detergent and hydrogen peroxide. The bones were drilled and joined with nylon thread to assemble the skeleton. The day of the practice, the skeleton was placed on the surgery table, the preserved tracheolaryngo-esophageal-cardiopulmonary unit was set up inside taking care of its anatomical position, and it was connected to a volume ventilator through the trachea to ensure good lung compliance, absence of leakage and lungs were insufflated under an inspiratory pressure of 14-23 cmH_2O simulating inhalation and exhalation inside the rib cage, after this, practices of endotracheal intubation, bronchoscope handling or biopsy training were performed. All of five preserved trachea-cardiopulmonary units had maintained their anatomical integrity; the lungs are elastic pieces with smooth texture along with distension and insufflation capacities. Our preserved tracheolaryngo-esophageal-cardiopulmonary unit has been shown to be functional for teaching and learning interaction in bronchoscope handling training, endotracheal intubation and biopsy practices.

Keywords: Medical Education, Biomaterial, Bronchoscope Handling, Endotracheal Intubation, Lung Biopsy.

INTRODUCTION

The ethical, legal and economic issues associated with teaching and learning on human patients, human cadavers, live laboratory animals and virtual reality simulators have prompted the use of numerous high fidelity bench models. We have been developing training programs to teach surgical skills to human and veterinary medical university students mainly based on cryopreservation and freeze drying methods obtaining excellent results (1-4). However, it has been necessary to implement new teaching and learning training models to practice orotracheal intubation, bronchoscope handling and taking biopsies. Developing real models for teaching and learning bronchoscope handling, endotracheal intubation and biopsy taking, are essential for acquiring skills in all of them procedures, this is fundamental for the early training of clinicians in all pulmonary specialties, at the same time, it allows the students to address both ethical and economic issues. Cardiopulmonary blocks preserved with Mc Cormick´s solution and glycerin-phenic acid have shown utility for teaching and learning pulmonary mechanical ventilation and plethysmography, which facilitates the understanding of different respiratory concepts such as spontaneous breathing, artificial ventilation and some related pulmonary pressure and volume measurements taking into consideration that under this treatment, preserved lungs maintain their capacity of insufflation when the cardiopulmonary block is connected to a ventilator, facilitating understanding and teaching about the respiratory complex system in junior surgeons of human and veterinary medicine as well as increasing their motivation to learn (5). Considering that preservation of cardiopulmonary blocks with McCormick solution and glycerin-phenic acid impregnation allows obtaining reusable, malleable, non-toxic and non-infectious pieces which had been useful in teaching and learning lung plethysmography and mechanical ventilation, the aim of this study was to evaluate the usefulness of a tracheolaryngo-esophageal-cardiopulmonary unit which were preserved with Mc Cormick´s solution and glycerin-phenic acid and its skeleton frame as a model in teaching-learning endotracheal intubation, bronchoscope handling, and lung biopsy training and to show the feasibility of using a real, reusable, transportable and low-cost preserved biomaterial.

MATERIAL AND METHODS

a) Experimental Design

Regardless of sex and age and after once owners authorized the euthanasia and the donation of the organs of their dogs who died of gastric dilatation volvulus (n=1: Boxer breeder, 3 years old, 25 Kg), hemorrhagic gastroenteritis (n=1: Mongrel, 7 years old, 22 Kg), viral canine distemper (n=2: Mongrel, 4 years old, 26 Kg. Labrador breeder, 8 years old, 30 Kg), and by aging (German Shepherd breeder, 13 years old, 35 Kg), tracheo-cardiopulmonary blocks including esophagus, larynx and tongue were harvested. All dogs were medium size (weighing between 22 and 35 Kg).

b) Cardiopulmonary blocks, trachea, larynx, esophagus and tongue procurement and preservation

The cardiopulmonary blocks, including trachea, larynx, esophagus and tongue were obtained by conventional surgical techniques and rinsed with 0.9% saline solution (PISA, Mexico) added with 1000U heparin (Inhepar,PISA) and 0.1ml antibiotic-antimycotic solution (A5955,Sigma,USA). Each cardiopulmonary block was dissected and washed with running water (3.5 liters/minute) through the trachea, esophagus and larynx. A perfusion through the trachea with McCormick's solution was performed until all the lobes of both lungs were completely filled, after this, each tracheolaryngo-esophageal-cardiopulmonary unit was placed during 60 days at room temperature inside a perfectly sealed polypropylene container entirely submerged in McCormick´s solution, where lungs were covered with a blanket in order to prevent lungs from floating in the solution. Subsequently, in the same way, a second round of perfusion with 60 days of preservation using glycerin-phenic acid solution was made (5-9).

d) Preparation and composition of McCormick's and glycerin-phenic acid solutions

A liter of McCormick's fixative solution was prepared as follows: in 900 ml of distilled water (900ml) dissolve 0.66 g of dibasic anhydrous potassium phosphate (cat: 3752-01, J.T.Baker, Mexico), 2.5 g of dibasic anhydrous sodium phosphate (cat: 3828-1, J.T.Baker, Mexico.), 1.7 g of ascorbic acid (A4403, SIGMA, USA), 8.5 g of salt of Prague [Mixture of 94% sodium chloride (cat:3624-01, J.T.Baker, Mexico) with 6% sodium nitrite (cat:3780-01, J.T.Baker, Mexico)] and 100ml of 40%

formaldehyde diluted in water (cat: 6411, Fairmont, Mexico). When McCormick´s solution is prepared, it is necessary to respect the strict order of addition of the reagents as they were above mentioned (5-7). A liter of glycerin-phenic acid fixative solution is prepared as follows: 200 ml of carbolic acid (89 parts/ million in 10% water) are added to 800 ml of chemically pure glycerin (5,9).

e) Skeleton preservation

Dogs were skinned and dissected by removing the ligaments and tendons of the whole body. The limbs, the skull of spine was completely disarticulated, all the bones were placed inside plastic-mesh bags which were boiled in water with detergent (1.66 g of detergent/1000ml water) (ROMA Laundry detergent, La Corona, México) during the time required to remove fat and soft tissue. When the water was cold, bones were washed by hand using water and detergent. Large bones such as femur, tibia and humerus were pierced with a small bore to remove the bone marrow, in the case of the skull; encephalon was macerated using a spatula through the foramen oval. Once the bones were perfectly clean, they were placed on a clean cloth for dried at room temperature and they were subsequently submerged in hydrogen peroxide (30 volumes at 9%, Meyer, Mexico) for 24 hours (6-7,10-12). With the help of a metal drill (1.19 mm, 3/64", Toolcraft, Mexico) a hole was made in each of the bones at the level of the articulations in order to join them using transparent monofilament nylon (0.90mm diameter Fishing line, Samyear, China) and two surgeon's knots (13).

TEACHING AND LEARNING INTERACTIONS

One hour prior to implementing the teaching and learning practices, the tracheolaryngo-esophageal-cardiopulmonary unit was removed from its storage box and both lungs were massaged with smooth and steady motions. The cardiopulmonary block was connected to a volume ventilator (Harvard Apparatus, USA) through the trachea to ensure good lung compliance and to make sure there was no leakage in order to keep the lungs working during the practices (Figure 1).

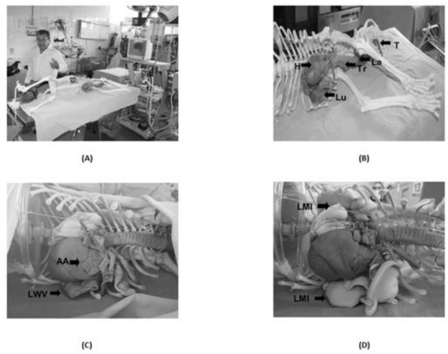

Figure 1: A) Canine Skeleton frame. B)Tracheolaryngo-esohageal-cardiopulmonar unit in posterolateral position. Tongue (T), larynx (La), trachea (Tr), lungs (Lu), and heart (H) are observed. C) Lungs without ventilation (LWV), atrial appendage (AA). D) Lungs with mild insufflation (LMI).

a) Endotracheal intubation

To perform endotracheal intubation practice, the skeleton was placed in lateral or supine position and the tracheolaryngo-esophageal-cardiopulmonary unit was fitted inside it, respecting its anatomical place. The lower jaw was clamped with a gauze and pulled it down with another gauze, the upper jaw and tongue were clamped and pulled them up. The laryngoscope was taken with the left hand, students advanced through the oral cavity until they reached the epiglottis cartilage, then it was lifted. With the right hand, the endotracheal tube with balloon 26f (ID: 6.5mm, ED: 8.7mm, Sensi Medical, Jayor, Mexico) was placed passing the epiglottis (the endotracheal tube contains a flexible guide placed up to the level of the cuff and has a slight curvature at the end). Passing the vocal cords the endotracheal tube was slid, the guide was removed, the cuff was inflated, and the absence of leaks was verified to insufflate both lungs under 14 cmH_2O inspiratory pressure, connecting the cardiopulmonary block through the endotracheal tube to a ventilator (Viasys Respiratory Care, AVEATM 16050) in order to simulate inspiratory movements of the lungs (Figure 2).

b) Bronchoscope handling

The bronchoscope handling practice was done at the end of the intubation training. Students handled a fiber optic bronchoscope (LF-DP, with light source CLH-250 and light guide cable WA03210A, Olympus, Japan) which contains a 65 cm working channel that reaches the tip of the bronchoscope, in addition, it has a small lever that moves the tip of the fiber optic bronchoscope forward and backwards at a 90° angle that makes it possible to insert the bronchoscope into any of the bronchopulmonary segments. Usually the small lever is operated with the left hand and the right hand is used to introduce the tip of the device through the glottis to the larynx and airways, so it is possible to explore the tracheobronchial tree. After this, students practiced a bronchoalveolar lavage, obviously, there was no need for anesthesia or use of other medications. The model was positioned in supine, the bronchoscope was introduced through the endotracheal cannula until the desired lobe was reached (right middle lobe); 20 mL of saline solution with a syringe were infused observing the flow through the bronchoscope, and maintaining wedge position, students proceeded to gently suctioning the solution to collect the lavage, moving gently the bronchoscope to optimize the suction (Figure 3).

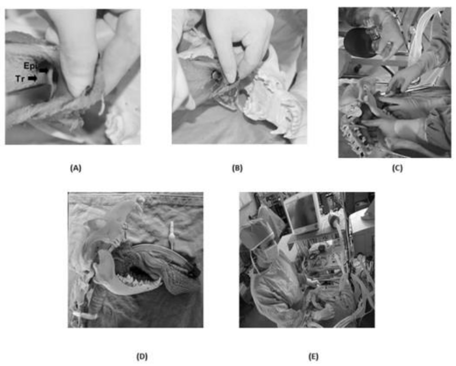

Figure 2: A) Structure identification: trachea (Tr) and epiglotis (Epi) exposure. B) Endotracheal cannula through the epiglotis. C) Intubation and ventilation with a cannula and connected to mechanical ventilation. D) Endotracheal cannula cuff. E) Tracheolaryngo-esohageal-cardiopulmonar unit with a cannula and connected to mechanical ventilation.

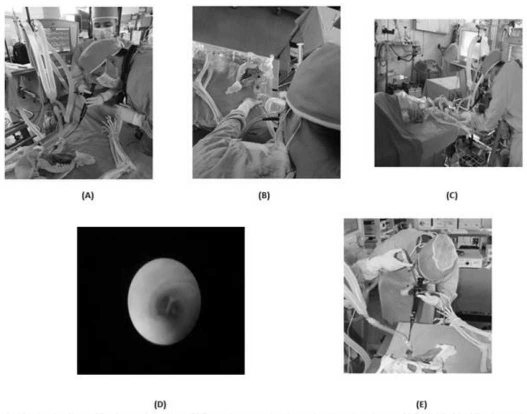

Figure 3: A) Introduction of the bronchoscope. B) Bronchoscope's at cervical trachea level. C) Distal light of the bronchoscope carina level. D) The carina is observed. E) Bronchoalveolar lavage.

c) Taking biopsies training

To perform biopsy taking training practices, the skeleton and the tracheolaryngo-esophageal-cardiopulmonary unit were placed in supine position for transbronchial biopsy or in any (left or right) lateral position for open biopsy. After intubation was practiced and lungs were connected to a ventilator (Viasys Respiratory Care, AVEATM 16050, USA) biopsy practices were made. Transbronchial biopsy was practiced through a fibro bronchoscope (350185, Olympus, Japan) introducing either a brush or forceps (FB-56D1, Olympus, Japan) into the working channel of the bronchoscope in order to obtain cells from the wall of the trachea or bronchial segments, on the other hand, an open biopsy was practiced simulating practicing an incision through the third intercostal space, where a Finochietto rib retractor (11, D. Simal, Inoxy, Belgium) was placed in order to separate the ribs and to expose the upper lobe of the right lung, the selected tissue was held with a vascular clamp (37-1180,Goodman 823, USA) isolating the portion of parenchyma, the lung was severed above the clamp, sutured by running stitch using 000 chromic suture (MH, 1/2 circle, 36.4mm, Ethicon, Johnson & Johnson, USA) and inspected for leaks of air (Figure 4).

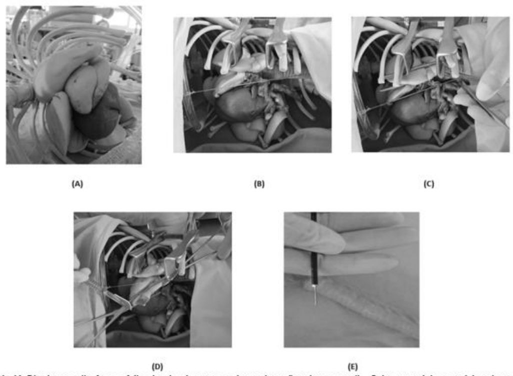

Figure 4: A) Diaphragmatic face of the tracheolaryngo-esohageal-cardiopulmonar unit. Pulmonary lobes and heart are observed. B) Ribs retraction with Finochietto and biopsy clamp placement. C) Ventral sight of the Diaphragmatic face of the tracheolaryngo-esohageal-cardiopulmonar unit. D) Biopsy of the pulmonary lobe. E) Biopsy clamp.

RESULTS

After treatment and preservation with McCormick's solution and glycerin-phenic acid, all five tracheolaryngo-esophageal-cardiopulmonary units including the tongue, maintained their structural integrity. A total of twelve students (n=12, 100%), six of them of human medicine (n=6, 50%) and six of veterinary medicine (n=6, 50%) performed the three practices (endotracheal intubation, bronchoscope handling and biopsies training). The evaluation reported by Ravenndra (14) was used to assess students in the endotracheal intubation practice in addition to bronchoscope handling. All students (100%), learned about the equipment characteristics and its handling, as well as how to clean it and keep it.

After students practiced orotracheal intubation, they inserted the bronchoscope controlling its orientation in order to keep the carina in the field of view, finally the bronchoscope was removed smoothly. The day of the biopsies training, the students returned to practice orotracheal intubation and inserted the fibro bronchoscope too. All students (n=12,100%) reconfirmed by themselves the vision of the carina, after this, a transbronchial biopsy was performed, finally, an open biopsy through the third intercostal space isolating the portion of parenchyma was made too by all students. Time values needed to perform each practice are shown in table 1. Mean values ± standar error were 4.062±0.264 minutes for endotracheal intubation practice, 8.050±0.343 minutes for bronchoscope handling practice, 12.425±0.616 minutes for transbronchial biopsy and 17.322±0.571 for open biopsy training.

DISCUSSION

As medical educators, we are always trying to identify new teaching and learning models to provide skills training in order that ethical, legal and economic factors have limited medical training associated with learning on human patients and live laboratory animals. We have reported (5) that the lungs of the cardiopulmonary blocks which were preserved with Mc Cormick´s solution and glycerin-phenic acid, maintain their capacity of pulmonary insufflation when they are connected to a ventilator, as a result, we had obtained a functional and reusable anatomical for teaching and learning model of pulmonary mechanical ventilation and plethysmography, facilitating understanding of different concepts and measurements related to physiology of the respiratory system and artificial ventilation, as maximal inspiratory pressure, pulmonary compliance, tidal volume inspired, airway resistance and the percentage of leak among others. In our experience, all students of medicine (human and veterinary) have improved their confidence and understanding in plethysmography and pulmonary mechanics (5). Based on these results, we decided to evaluate the usefulness of a tracheolaryngo-esophageal-cardiopulmonary unit which were preserved with Mc Cormick´s solution and glycerin-phenic acid that was placed inside a skeleton frame in three interrelated teaching and learning practices: 1) endotracheal intubation, 2) bronchoscope handling, and 3) lung biopsy taking, so that, we harvested five dog's cardiopulmonary blocks including the trachea, the larynx, the esophagus and the tongue, which were preserved with McCormick's-glycerin-phenic acid treatment. McCormick's-glycerin-phenic acid preservation time it was 120 days per tracheolaryngo-esophageal-cardiopulmonary unit. The first 60 days, the pieces were immersed into a phosphate saline solution added with ascorbic acid and Prague salt. It is well known that Prague Salt, a mixture of sodium chloride with sodium nitrite has been used as a curing salt in meat preservation by dehydration. The second part of the preservation technique includes 60 days given treatment with phenic acid in order to get free of fungi and bacteria pieces. Once the preservation time has elapsed, each of the tracheolaryngo-esophageal-cardiopulmonary units was stored inside a hermetically sealed polypropylene box held at room temperature. The only tedious procedure after preservation of tracheolaryngo-esophageal-cardiopulmonary units with McCormick's-glycerin-phenic acid treatment, it is that approximately one hour before connecting the cardiopulmonary block to a volume ventilator in order to perform any practice, the lungs must be massaging using smooth and steady motions with the intention of ensuring an excellent lung compliance and to make sure there was no leakage. So as to have a protective support for the tracheolaryngo-esophageal-cardiopulmonary units, we decided to preserve skeleton frame. Literature on techniques for animal skeletons preservation is limited, Allouch (15) reported a technique for camel, horse, sheep, dog, ostrich and birds skeletons preservation where bones were boiled with sodium hydroxide, degreased and cleaned with gasoline, dried at room temperature and bleaching using hydrogen peroxide, however, in order to reduce toxicity to preserve the skeleton frame, we avoided the use of sodium hydroxide and gasoline because boiling the bones in water with detergent and bleaching them with hydrogen peroxide was more than enough to get them clean and white. Boiling time is a very important factor, because boiling may cause rot and texture fatty with foul smell later and extra boiling leads to fragility and des-integration of thin bones like skull and ribs. Once the washing and bleaching all of the bones was finished, the skeleton was assembling joining the bones with nylon thread and it was placed in the surgical table in lateral decubitus position and a tracheolaryngo-esophageal-cardiopulmonary unit was introduced inside the skeleton starting from the thorax and ending in the jaw respecting its anatomical place which can be placed in lateral or supine position allowing students to be in contact with the axial portion of the skeleton (head, neck, spine, ribs, and sternum) as well as tongue, trachea, larynx, esophagus, heart and lungs. Twelve medical students performed four serial practices starting with tracheal intubation and ending with open lung biopsy training, neither of them had experience about endotracheal intubation nor contact with a bronchoscope and much less they had had the opportunity to take a lung biopsy.

Fiber optic bronchoscope was introduced by Ikeda in 1967 following advances in the knowledge of optical properties of glass fibers in the mid-1950s (16) and has been expanded to confirmation of proper placement of single- and double-lumen tubes, evaluation and difficult airway management and for indirect techniques of endotracheal intubation and fiber optic airway management skills enhanced the ability to manage many of the anticipated and even unanticipated difficult airway (14,17)because it reduces the number of attempts, time required for intubation, incidence of airway injuries and risk of aspirations and helps to avoid need for surgical airway however, the training program can be affected due to various reasons such as non-availability of the fiber scope, trainers and, lastly suitable patients. In many institutions, the instrument is in the custody of chest physicians or thoracic surgeons (14). Although basic airway management is a major component of resuscitation, it has been reported residents lack basic airway skills (18). The Fiber optic airway management skills practice involves development and execution of a set of complex cognitive, phychomotor and judgmental skills along with sound clinical knowledge and training in the skill has been realized through methods as didactic lectures, workshops with hands-on training on the patients under supervision (14), as well as use of airway training mannequins, simulators, virtual reality trainers and cadavers (14,17). Training under experienced staff is the most effective method, but the ethical correctness of subjecting a patient to a procedure by a novice has been questioned (14). Ethical questions arise concerning the appropriateness of using real patients as training resources. Much of this debate centers on sensitive tasks as those that involve potential risk of harm to patients as endotracheal intubation (18). Practice in the mannequins or different types specialized airway trainers have been found to enhance the effectiveness of learning and to improve the outcome as choose-the-hole model is a simple model that can be developed locally. It was designed by Dr. Arthur Frederic David Cole of the University of Toronto, Canada where three wooden panels with holes are mounted on a wooden base and syringe barrels are inserted into the holes in different combinations (14). Fiber optic orotracheal intubation skills training on a simple model is more effective than conventional didactic instruction for transfer to the clinical setting. Incorporating an extraoperative model into the training of fiber optic intubation may greatly reduce the time and pressures that accompany teaching skill in the operating room (19). Our tracheolaryngo-esophageal-cardiopulmonary unit is a useful physio anatomical model where fellows are able to practice orotracheal intubation and training in oral route bronchoscopy while lungs are working because they are connected to a ventilator, besides that the students are in contact with the axial portion of the skeleton (head, neck, spine, ribs, and sternum) along with the tongue, trachea, larynx, esophagus, heart and lungs. Skeletons models are useful to demonstrate osteology, applied anatomy and to promote scientific knowledge (14). Anatomy comprehension is considered the most important course in the preclinical stage by employing the cognitive learning process (15). Everson et al. (20), reported a biological simulator as a viable,

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accessible and affordable tool to simulate gastrointestinal lesions, allowing training in endoscopy with a high degree of similarity in the endoscopic appearance designed a frame made of rigid glass fiber with adult human shape that included head, trunk and abdominal cavity with slits that allowed the access of material to the conventional electrocoagulation system. Inside the rigid frame blocks of porcine, canine and bovine tissue including esophagus stomach, duodenum, intestines (thin and thick), liver and gallbladder were placed, all of them were preserved by freezing at -40°C for 48 hours and thawed in water at 45°C for two hours after different and reproducible gastrointestinal lesions that do not require large technological resources were created. Everson's biological simulator is a high-fidelity bench model of cryopreserved organs that can be used as a practical, reproducible, low cost and high fidelity surgical model allowing training in endoscopy. In our experience, cryopreserved tissues or organs are very useful training models that allow to improve the surgical abilities of the fellows, in fact, we have developed training programs to teach surgical skills based on laboratory animal organs as arteries (2), esophagus (4),trachea (1), and stomachs (3) which were harvested at the conclusion of different research studies and stored either by cryopreservation (1-3)or lyophilization (4), however is unavoidable to have a tissue bank because these methods of preservation do not allow the obtaining of reusable biomaterials in addition to the fact that cryopreserved tissues may be friable or easily broken (2-3) in contrast with McCormick's-glycerin-phenic acid preservation that allows to obtain reusable organs (5,8-9). McCormick's-glycerin-phenic acid solution provides a great advantage, it is an appropriate technique to fix and preserve lung properties such as elasticity, distension and insufflation capabilities when cardiopulmonary blocks are connected to a ventilator. Another important advantage of this preservation technique is that the anatomical pieces can be stored inside an airtight container maintained at room temperature for many years. The basic elements of any interventional procedure are diagnostic bronchoscopy, and tissue sampling using forceps (endo and transbronchial biopsies) or needle aspiration, and although bronchoscopic techniques continue to evelop rapidly, basic procedures such as bronchoalveolar lavage, transbronchial lung biopsy and transbronchial needle aspiration play a decisive role in pulmonary disease diagnosis and interventional pulmonologists must continue to be trained in the learning of these methods. The effectiveness of a theoretical and practical course on virtual reality simulators, on animal or cadaver models has been fully demonstrated by scientific studies (16). After fellows were able to performing both of two procedures (intubation and bronchoscopy including a bronchial lavage) in completely safety, transbronchial biopsy through a fibro bronchoscope and an open biopsy simulating an incision through the third intercostal space were practiced. To practice the first one, an Olympus bronchoscope which its principal characteristics of the fiber, is a working channel entrance in the proximal portion that goes all the way to the tip (65 cm long) was used. It also has a small plank that mobilizes the tip back and forth in a 90° degree, this makes possible to conveniently explore the bronchial tree. Likewise in the channel forceps can be introduced for making biopsies of lung mucosa, or for puncture of the carina nodes. Also, through the channel previously mentioned is possible to introduce brushes for bronchoalveolar lavages, for obtaining wall trachea cells and the bronchial segments. These characteristics make biopsy possible and could be used as a method for teaching its handling too. It was possible to take a biopsy of the apical and posterior lung segments thanks to its flexibility.

CONCLUSION

The treatment of organs and tissues with Mc Cormick's solution and glycerin-phenic acid shows the feasibility of using a real, reusable, transportable and low-cost preserved biomaterial allowing the obtaining of malleable, non-toxic, non-infectious and free of fungi and bacteria anatomical models where lungs maintain their capacity of pulmonary elasticity, distension and insufflation. Our preserved tracheolaryngo-esophageal-cardiopulmonary unit and its skeleton frame could increase successfully skills and performance in teaching-learning endotracheal intubation, bronchoscope handling including bronchoalveolar lavage practice and lung biopsy taking training and could be used for different training and assessment related with thoracic surgery.

REFERENCES

[1]. Sotres-Vega A, Villalba-Caloca J, Ramirez-Zamora F, et al (2012) Cryopreserved tracheal segments: a new tool for bench surgical training in thoracic surgery. Acta Cir Bras 27:585-8

[2]. Sotres-Vega A, Olmos-Zúñiga R, Jasso-Victoria R, et al (2002) Arterias caninas preservadas como material didáctico para la realización de anastomosis vasculares. Rev Inst Nal Enf Resp 15:78-83.

[3]. Avelina Sotres-Vega, Jaime Villalba-Caloca, Shely Azrad-Daniel, et al. Surgical training with cryopreserved rat stomach. J Vet Med Educ 43(4):420-26,2016.

[4]. Sotres-Vega A, Osorio-Necoechea ME, Salas-Galindo G, et al (2013) Bench surgical training with lyophilized esophageal segments. Acta Cir Bras 28:619-23

[5]. J. Pineda-Gutiérrez, A. Sotres-Vega, J. Villalba-Caloca, et al. Preservation of cardiopulmonary blocks: A real and interactive biomaterial for teaching and learning lung plethysmography and mechanical ventilation. International Journal of Engineering Research & Science (IJOER) 2(4):162-66,2016.

[6]. J.L. Nieto Bordes, C.G.García Tovar, Ma.R. PIchardo Molinero. Técnicas para preservar piezas anatómicas, Univesidad Nacional Autónoma de México, Facultad de Estudios Superiores Cuautitlán, MX: Ultradigital Press S.A. de C.V. 2014 p17-20,24-30.

[7]. Cecilia López Matías. Manual básico de técnicas de conservación y museografía, Universidad Autónoma "Benito Juárez" de Oaxaca, UABJO. Escuela de Medicina Veterinaria y Zootecnia. Tesis de licenciatura, México. 2010 pp 3-28, 62-70.

[8]. G. Prat D. Costi, F.Siris, et al. Mc. Cormick, our experience in anatomical preparations and fresh formolized. Revista Cientifica de la Facultad de Ciencias Médicas 4:1-11,2014.

[9]. A. Muñetón-Gómez, J.A.Ortiz. Preparación en glicerina: Una técnica para la conservación prolongada de cuerpos en anatomía veterinaria. Rev Med Vet 26:115-122,2013.

[10]. Ajayi A, Enjomariegwe O, Iselaiye O.T. A review of bone preparation techniques for anatomical studies. Malaya Journal of Biosciences 3(2):76-80,2016.

[11]. Mubashir Hussain, Naveed Hussain, Hufsa Zainab, et al. Skeletal preservation techniques to enhance veterinary anatomy teaching. IJAVMS1:21-3,2007.

[12]. Greene E.A, Smith K.R, Pendergraft J.S, et al. Technical note: Equine skeletal preservation techniques to enhance teaching effectiveness. J Anim Sci 71:2270-74,1993.

[13]. Gerardo Cañete Betancourt, José Miguel Sánchez Pellitero, Liván Noda Cuellar. Ensamblaje artesanal de un esqueleto canino mediante variantes de la osteotecnia. REDVET 15(9):1-15,2014.

[14]. Raveendra US. Teaching and training in fiberoptic bronchoscope-guided endotacheal intubation. Indian J Anaesth 55 (5): 451-455,2011.

[15]. Allouch G.M. Scientific technique for skeletons preservation and preparation of anatomical models to promote veterinary anatomy. J Vet Anat 7(2):133-39,2014.

[16]. Valentini I, Lazzari L, Michieletto L, et al. Competence in flexible bronchoscopy and basic technique. Panminerva Med 2018.

[17]. Stephen R. Collins, Randal S Blank. Fiberoptic intubation: an overview and update. Respir Care 59(6):865-80,2014.

[18]. Eric R. Weinberg, Marc A. Auerbach, Nikhil B. Shan. The use of simulation for pediatric training and assessment. Curr Opinion Pediatr 21(3):282-7,2009.

[19]. Naik VN, Matsumoto ED, Houston PL, et al. Fiberoptic orotracheal intubation on anesthetizes patients:do manipulation skills learned on a simple model transfer into the

operating room. Anaesthesiology 95(2):343-8,2001.

[20]. Everson L.A. Artifon, Asadur J. Tchekmedyian, Kaie Fernandes, et al. Endoscopy training by using ex vivo and simulators: a new teaching tool. Rev Gastroenterol Peru 34(4):325-31,2014.

CONFLICT OF INTEREST

The authors have no financial interest to declare in relation to the content of this article.