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Medical training in orotracheal intubation with acrylic box in pediatric SARS-CoV-2 patients decreases exposure time

El entrenamiento médico en la intubación orotraqueal con caja de acrílico en pacientes pediátricos con SARS-CoV-2 disminuye el tiempo de exposición

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ABSTRACT. Introduction: in the SARS-CoV-2 pandemic, the modification of the intubation technique using the aerosol box, in order to reduce exposure to aerosols generates anxiety in Health Workers (HCWs), by increasing the degree of difficulty and time of endotracheal intubation (IT). Simulated intubation environments allow to measured IT and also increase intubation ability and decrease IT. **Objective:** to measure IT pre (without box without training -SS-, with box without training -CS-, with box with training -CC-) and post educational maneuver. **Material and methods:** retrospective, comparative, before and after; with physicians trained in a simulated environment. **Results:** n = 82, age 29 years (27 to 31 years), clinicians 69.5%, residents 82.9%. IT: SS 35 s (27-47.25 s), CS 39.5 s (28-56.5 s) and CC 22 seconds (17.5-30 s), p = 0.0001. Higher IT of clinical vs surgical physicians SS 39 s (30-52 s) versus 32 s (24-34 s), p = 0.004; CS 42 s (33-59 s) versus 28 s (21-43 s), p = 0.016; CC 25 s (20-35 s) versus 19 s (16-21 s) p = 0.018. Higher TI novice vs experienced SS 68 s (39-135 s) versus 34 s (27-46 s), p = 0.058; CS 144 s (84-210 s) versus 38 (28-54 s), p = 0.001, CC 46 s (30-55 s) versus 22 s (17-30 s), p = 0.030. Using the device without training increased IT, but post-training IT decreased in all groups -16 s (-26 to -7 s), which was more noticeable among novices -98 s (-163 to -45.5 s) and the clinical

RESUMEN. Introducción: en la pandemia por SARS-CoV-2, la modificación de la técnica de intubación utilizando dispositivos de barrera (aerosol box) para disminuir la exposición a aerosoles generó ansiedad en los trabajadores de la salud (TS), al incrementar el grado de dificultad y el tiempo de intubación endotraqueal (TI). Los ambientes simulados de intubación incrementan la habilidad para la intubación y disminuye el TI. **Objetivo:** medir el TI pre y posmaniobra educativa (sin caja sin entrenamiento -SS-, con caja sin entrenamiento -CS-, con caja con entrenamiento -CC-). **Material y métodos:** retrospectivo, comparativo, con médicos capacitados en el ambiente simulado. **Resultados:** n = 82, clínicos 69.5%, residentes 82.9%. TI: SS 35 s (27-47.25 s), CS 39.5 s (28-56.5 s) y CC 22 s (17.5-30 s), p = 0.0001. Mayores TI de clínicos versus quirúrgicos SS 39 s (30-52 s) versus 32 s (24-34 s), p = 0.004; CS 42 s (33-59 s) versus 28 s (21-43 s), p = 0.016; CC 25 s (20-35 s) versus 19 s (16-21 s), p = 0.018. Mayor TI novatos versus experimentados SS 68 s (39-135 s) versus 34 s (27-46 s), p = 0.058; CS 144 s (84-210 s) versus 38 s (28-54 s), p = 0.001; CC 46 s (30-55 s) versus 22 s (17-30 s), p = 0.030. El uso del dispositivo sin entrenamiento aumentó el TI, pero en todos los grupos hubo disminución del TI posterior a la capacitación -16 s (-26 a -7 s), más notoria entre los novatos -98 s (-163 a -45.5 s) y el grupo

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group -18.5 s (-32 to -7 s). **Conclusion:** the use of devices with training can be efficient in terms of IT, regardless the degree of experience and type of medical specialty.

Keywords: aerosol box, clinical simulation, simulated learning, acrylic box .

clínico -18.5 s (-32 a -7 s). **Conclusión:** el uso de dispositivos puede ser eficiente en términos de TI con un entrenamiento independientemente de la experiencia y especialidad médica.

Palabras clave: aerosol box, simulación clínica, aprendizaje simulado, caja de acrílico.

INTRODUCTION

The transmission pathway of SARS-CoV-2 is airborne, via droplets or aerosols. Procedures that generate aerosols (droplets less than 5 microns), such as endotracheal intubation, expose health care workers (HW) to risk. At the beginning of the pandemic, it was considered that a transparent acrylic intubation box or aerosol box that partially isolate the patient can increase the protection of the HW, specially in places with little access to personal protective equipment (PPE) or videolaryngoscopes.[1-5]

The intubation box (IB) is an acrylic box that does not have a standardized design, it consist of an acrylic device of 6 mm thick, the dimensions of the original design (40 cm high in the distal wall, 50 cm wide and 40 cm deep, the front face is divided into two walls one at 90º of 25 cm high, on which is the second with an angle of 70º of 21 cm for a total of 46 cm, the ceiling of the box measures 25 cm deep. The anterior face has two circular holes of 12.5 cm in diameter placed at 12.5 cm from the base) were modified from the original proposal by Hsien-Yung and reproduced by Canelli, because of the smaller dimensions of the pediatric patient.[6,7] The intubation was then more difficult, which generated distress in the HW. There are observations that the use of the intubation box by expert anesthesiologists lengthens the intubation time in simulated environments, but that it has no clinical significance.[8-10] Even though the current guidelines for airway management in the patient with COVID-19 recommend the use of the videolaryngoscope, since it confers a lower degree of difficulty and decrease in intubation time (although in the last systematic review of Cochrane there were no significant differences between the intubation time with both equipment), it is an equipment that may not be accessible in all the health centers.[3,4,11,12]

The use of the aerosol box is suggested as an additional element or in certain moments when there is a deficit of personal protection elements, that is, the box must be used without ignoring the other recommended protective elements.[13] Several studies have evaluated the risks of using the aerosol box during intubation with greater risk of exposure to aerosolized particles, as well as obstruction of the procedure, with variable results.[9,10,12]

The simulated education spaces are educational tools that facilitate the knowledge and skill acquisition for health care[14-16] and during the beginning of the pandemic it was crucial to prepare the HW in simulated environments that would give them the security to perform procedures in optimal times with the personal protection tools available, reducing anxiety and increasing the skills of the clinicians, translating into real life reduction of the risk of exposure to aerosols.[17]

A clinical simulated environment for the pediatric endotracheal intubation dexterity was design in the unit that includes the development of sedation, relaxation and endotracheal intubation skills in a pediatric manikin, with the addition of the acrylic aerosol box, with the described characteristics and depicted in *Figure 1*.

Our objective was to measure the effect of education in a simulated environment on effective intubation time (IT), with and without the use of the acrylic box as personal protective material before and after training, and to compare according to the level of experience of the HW, the type of speciality and the type of hiring with in the hospital.

MATERIAL AND METHODS

A retrospective, comparative study was carried out before and after an educational maneuver in a simulated environment in a third level pediatric hospital in Mexico City.

Doctors of several pediatric specialities were included, who were classified into clinical and surgical specialities,

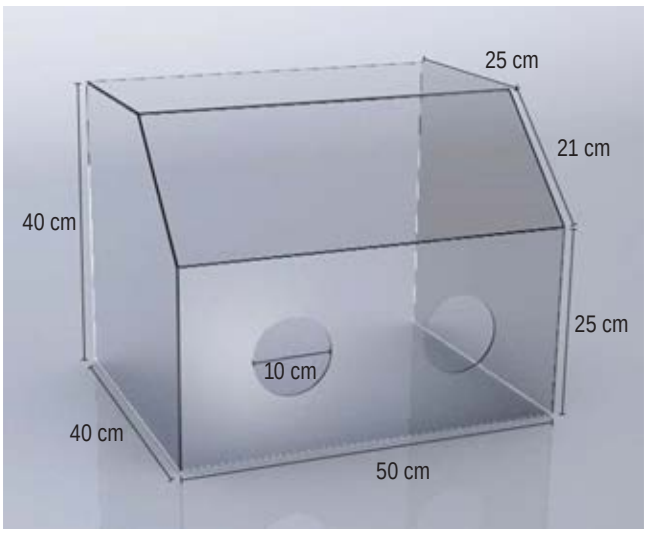

Figure 1: Acrylic box designed for this study.

and by the type of work they perform in the hospital as residents in training or seconded personnel. In addition, physicians were classified according to their intubation experience, those with no experience in endotracheal intubation (novice) and those who had experience were called experienced.

The educational maneuver consisted of training for pediatric endotracheal intubation with a pediatric manikin by adding an acrylic box between the doctor and the manikin. The educational maneuver was developed in workstations, where the doctors were instructed in teams of two resuscitators.

Each stations consisted of two tables, the first with audiovisual equipment, the second with simulation equipment (Laerdal brand neonatal intubation head, Kawe brand laryngoscope, with Miller blade number 0, intubation equipment, acrylic box designed by the biomedical team of the hospital). Trained doctors used in the simulated environment only gloves as personal protective equipment.

The training was divided into three phases:

1. Audiovisual explanation of 10 minutes, where the generalities of the technique of intubation, team roles and rapid sequence of intubation were explained, as well as the modified technique for intubation with the acrylic box.
2. The team's instructors made a demonstration of the intubation procedure, by simulation, with the pediatric manikin *(Figure 1)*.
3. The last phase was divided into the following sections:
   a. The intubation time without the acrylic box was timed with the technique that doctors routinely use (it was called time WITHOUT box and WITHOUT training -WW-). The IT was measured with chronometer from the moment the laryngoscope was taken until the tube position check was done when inflating with self-inflating bag.
   b. The intubation was timed using the acrylic box (it was called time with BOX, WITHOUT training -BW-) The IT was timed with chronometer starting with the arms out of the box and finished until the position of the endotracheal tube was checked.
   c. Five intubation exercises without chronometer were performed with the instructor on a personalized basis, where feedback and detailed correction of the technique were performed.
   d. Once again, the intubation time was timed with acrylic box after training (it was named with BOX, with TRAINING -BT-). IT was timed with chronometer starting with the arms out of the box and finished until the position of the endotracheal tube was checked.

Table 1: Characteristics of the population and intubation times.

	Total sample n (%)
Male sex	24 (29.3)
Age [years]*	29 [27-31]
Speciality type	
Clinicians	57 (69.5)
Surgical	25 (30.5)
Experience	
Novice	4 (4.9)
Experienced	78 (95.1)
Type of hiring	
Residents	68 (82.9)
Seconded	14 (17.1)
Time WW s,*	35 [27-47.25]
Time BW s,*	39.5 [28-56.5]
Time BT s,*	22 [17.5-30]

WW = without box without training. BW = with box without training. BT = with box with training. s = seconds.
* Data expressed in median [interquartile range].

Intubation times without box and without training -WW-, with box and without training -BW- and with box and with training -BT- were compared. The times were compared with the Wilcoxon test, the variables with medians and interquartile range are described. The statistical analysis was done with the SPSS program.

RESULTS

82 doctors were included in this study. The characteristics of the sample are found in *Table 1*, where it is highlighted that the majority were female (71%), the median age was 29 years old (27 to 31), most of the clinical group (69.5%) and residents in training (82.9%), there were four people who had no experience in intubating (4.9%).

Regarding the degree of training: three (3.6%) were general practitioners hired for the COVID area, 32 (39%) second and third year pediatric residents, 22 (26.8%) qualified pediatricians and sub specialists and 25 (30.48%) from the surgical area.

The WW intubation times for all the population were 35 seconds (27-47.25 s), BW of 39.5 seconds (28-56.5s) and BT of 22 seconds (17.5-30.0 s), resulting in a significant difference generated from training (p= 0.0001).

There were no differences for intubation times between the sexes in any of the three timed phases (WW p = 0.808, BW p = 0.808, BT p = 0.321), nor between the type of in-hospital hiring (residents versus seconded personnel WW p = 0.769, BW p = 0.379, BT p = 0.951). No correlation was observed between

intubation times and the age of who intubates (WW rho = -0.173, p = 0.302; BW rho = -0.035, p = 0.379; BT rho = -0.065, p = 0.282).

A significant difference in intubation time was observed in the three timed phases between clinical and surgical doctors, having shorter times the doctors of surgical speciality systematically: clinical WW 39 s (30-52 s) versus surgical 32 s (24-34 s), p = 0.004; clinical BW 42 s (33-59 s), surgical 28 s (21-43 s), p = 0.016; and clinical BT 25 s (20-35 s) and surgical 19 s (16-21 s), p = 0.018.

Regarding intubation experience it was also observed a significant difference in the three intubation times between novices and experienced: novices WW 68 s (39-135 s), experienced 34 s (27-46 s), p = 0.058; novices BW 144 s (84-210 s) and experimented 38 s (28-54 s), p = 0.001; and novices BT 46 s (30-55 s) and experimented 22 s (17-30 s), p = 0.030.

For all the groups there was a significant decrease in intubation times, BT versus BW *(Table 2)*. It stands out that in the group of clinicians the best decrease in the intubation time after training was noticed.

DISCUSSION

The number of COVID-19 patients requiring endotracheal intubation can increase to until 40%.[18-20]

According to the Begley results *et al.*, intubation with acrylic box increases the execution time, however, the learning based on simulation can address those challenges.[10] We have observed that the group that systematically takes the longest to achieve intubation is that of clinician, and that with training in simulated environments it is the most benefited in reducing intubation time with the use of aerosol box. In this sense, the clinicians are given two safety measures for their clinical practice: the first, the use of a barrier that decrease exposure to aerosol and, the second, the dexterity of achieving intubation in less time.

In this study it was not possible due to limitation of personal protection resources to carry out the training with this equipment, which can influence the IT in real life. The debate persists as to whether this procedure can lengthen IT by introducing a new device. Álvarez *et al.* observed that when using aerosol box and personal protective equipment in a simulated scenario hinders intubation maneuver and may prolong execution time; in inexperienced personnel, the aerosol box has been shown to increase IT. A study carried out in anesthesiology residents found that despite previous training in simulated environments, IT with acrylic box increased significantly compared to IT without box; however, the sample of this study was limited.[21] For Fong *et al.* there were no significant differences between IT with box and without box, with a difference of seconds in simulated scenarios with normal airway, only during difficult scenarios where not only was IT increased, but also more intubation attempts were required; although several studies have found that the use of the aerosol box slows down the procedure even in experimented airway specialists, due to greater difficulty in handling the devices, reduction of arm movements inside the box, increase in cognitive load by having to systematize a new process and lack of experience. Some other authors conclude that the aerosol box is clinically irrelevant as long as the operator is experienced in handling the airway, this under normal conditions.[9,10,12,22-28]

Starting from the original box, several modifications have been made that have decreased the limitations originally published, recently Kim *et al.* evaluated IT with different aerosol box designs in manikins with normal and difficult airway, finding that a modification in the box reduce IT, without finding significant differences in IT without aerosol box versus modified aerosol box for both normal and difficult airway, which gives protective benefit without delaying the intubation time.[29]

In our study, training in simulated environments improved the intubation time, even compared to intubation without box, similar to what was reported by Lima *et al.*, who found the IT improved after five intubation maneuver for each participant with box and without aerosol box, with similar times to what was reported in our study.[30] This again opens up the need for continuing education in essential skills, as it shows that clinicians are required to have ongoing training in simulated environments to improve their performance under stressful conditions and increased cognitive load. The simulation, in addition to being a controlled learning environment, provides information to modify or improve the systematization of processes. Colman *et al.*, with biomedical engineering help, manage to adapt the acrylic box based on the information of each participant after use it in simulated environments.

Table 2: Intubation time with acrylic box after training.

	Reduction of intubation time with use of box after maneuver, seconds	p
Total of population	-16 (-26 a -7)	
Residents	-14 (-25 a -7)	0.188
Seconded	-19 (-57 a -11)	
Clinicians	-18.5 (-32 a -7)	0.096
Surgical	-12 (-21 a -7)	
Novices	-98 (-163 a -45.5)	0.001
Experienced	-15 (-24 a -7)	

It is required that doctors have ongoing access to training to prevent skills from being lost over time. Young generations perform better in learning in simulated environments compared to the seconded group, making it an area of opportunity for health personnel training centers.

The particular box used in this study was a modification to the original model, since the adults dimensions differ from the pediatric population. In this project, the ability to limit the generation of aerosols or avoid exposure was not assessed, nor was the time with complete PPE evaluated, since these were reserved for the clinical care of patients, the issue of the removal of the device was not explored to ensure that the staff did not suffer further exposure. These are open lines of research and it is not the intention of this observation to give an opinion on these aspects.

CONCLUSION

Training in the endotracheal intubation procedure in a simulated intubation environment with the use of acrylic box, in times of COVID-19 pandemic, in a pediatric hospital, decreased the exposition in time to aerosols timed by the procedure time. The simulated environment significantly favors endotracheal intubation skills in stressful TS situation, thereby improving rapid and effective action in a state of severe airway compromise.

This study has several limitations. In first place, was not possible to carry out the training with the entire PPE given the scarcity that existed at the beginning of the pandemic. In second place, we only evaluate intubation time after training in manikins with normal airway, so our results are limited.

The main objective of this work was to measure the impact of the educational maneuver after the training of the use of aerosols in a simulated environment, we consider that given the significant reduction of IT and better performance of the TS after the educational maneuver, the aerosol exposition time can be reduced, so all hospitals should consider these educational resources in the continuing training of their personnel.

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