

Uncovering the Complexities of Intubation in Covid-19 Patients to Enhance Online Teaching: A Literature Review

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ABSTRACT

Background: Intubation is a crucial procedure used to maintain an open airway in patients who are deeply sedated, unconscious, or under anesthesia. It enables controlled ventilation and administration of oxygen during surgeries, severe illnesses, extensive trauma, or following cardiac arrest. Difficult intubation poses a significant risk to patients' well-being and necessitates comprehensive training programs for healthcare providers. With the rise of online teaching, it is essential to explore and understand the complications associated with difficult intubation to develop effective online training programs.

Methods: A literature review was conducted to examine the relevant literature on intubation complications and online teaching approaches. Electronic databases, including PubMed, Embase, and Scopus, were searched using keywords such as "intubation complications", "difficult airway", "online teaching", and related terms. Studies published from January 2018 to September 2022 were included. The selection criteria focused on articles that addressed the complications of intubation, online teaching strategies, and their impact on healthcare provider training.

Results: The literature review identified 23 relevant studies that met the inclusion criteria. The findings highlighted the significance of understanding and addressing the complications associated with difficult intubation in online teaching programs. Various approaches were explored, including virtual simulations, video-based modules, and interactive online platforms. These methods demonstrated promising results in improving healthcare providers' knowledge and skills related to intubation, ultimately enhancing the patients' safety.

Conclusion: This literature review emphasizes the importance of integrating the complications of difficult intubation into online teaching programs for healthcare providers. The findings support the utilization of virtual simulations, video-based modules, and interactive online platforms as effective tools in enhancing training outcomes. Online teaching provides a flexible and accessible platform for healthcare providers to learn and practice intubation techniques in a simulated environment, thus improving their preparedness for real-life scenarios.

Keywords: Intubation, Ventilation, Corona, Patient, General Anesthesia, Online Teaching

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Introduction

Covid-19, as a contagious disease, is one of the common diseases between humans and animals, which is caused by the coronavirus family, which is one of the RNA viruses (1-3). The Covid-19 virus is one of the most dangerous viruses in this family. According to the report of the World Health Organization, until June 2020, about 6.5 million people were infected all over the world and more than 390 thousand deaths due to this disease were reported. Iran is the 25th country which was infected with this virus (4-6). In Wuhan, China, the mean age of those who died was 50 years, and the number of reports was higher in men. Approximately 81% of patients had mild symptoms, and only 14% of them had severe symptoms including pneumonia and shortness of breath. About 5% of severe cases faced respiratory failure, infectious shock, and failure of other body organs. Fever and cough were reported as the most common symptoms, especially in children (7-10).

In the study by Chen et al., the incidence rate was slightly higher in men. Of course, in the study by Lee et al., the incidence rate was higher in women. Previous studies showed that in deceased patients, the age above 60 years accounted for more deaths (11-13). Due to the fact that elderly people are more prone to death and the presence of underlying diseases among elderly is higher, these people suffer increased risk of death (14). The decrease in the consciousness level was significantly higher in the deceased. Paying attention to the clinical signs and symptoms of the patients who died shows that these

patients had serious conditions upon arrival. The checking blood oxygen saturation shows that most of these patients had spo2 lower than 93% (15-17).

Given that Covid-19 shows more deterioration in people with underlying diseases such as blood pressure, and that these patients are more at risk of coagulation and thromboembolism problems during long-term hospitalization, using vasoconstrictor drugs in Covid-19 patients is of utmost importance (Figure 1).

As to blood products injection, although a small percentage of patients required blood products injection, long-term hospitalization in the intensive care unit alone is a factor in causing anemia in patients; thus, the availability of blood products and the safety of injection should be more considered (18-20). The Covid-19 pandemic represents the most extensive global public health crisis (21, 22). Intubation is necessary when the airways are obstructed or damaged or when breathing is not possible. Intubation plays a crucial role in the management of Covid-19 patients with severe respiratory distress. When the disease progresses to a critical stage, some individuals may experience acute respiratory failure and require mechanical ventilation for their survival. Intubation involves the insertion of an endotracheal tube into the patient's airway to maintain an open pathway for oxygen delivery and removal of carbon dioxide (23). In Covid-19 cases, intubation presents unique challenges due to the highly contagious nature of the virus and the need for strict infection control measures.

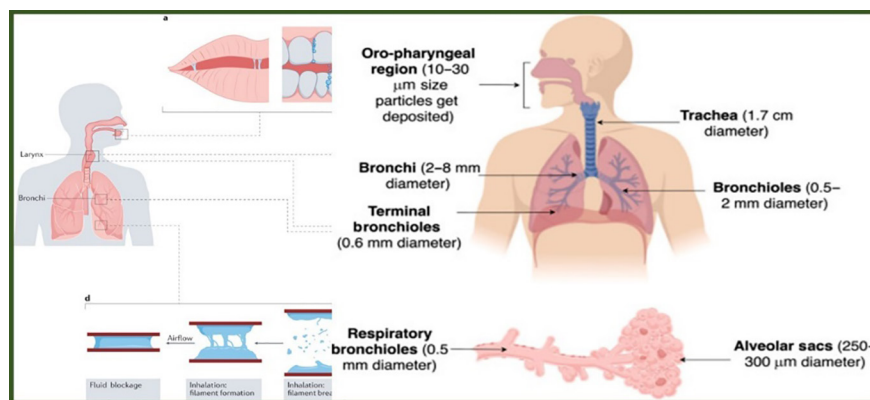


Figure 1: Exhalation and deposition of particles

Healthcare professionals must use personal protective equipment (PPE) to minimize the risk of transmission during the intubation procedures. Additionally, specific precautions such as using a negative pressure room and minimizing the number of healthcare workers involved are implemented to safeguard the healthcare team (24).

Online teaching on intubation in Covid-19 patients has emerged as a crucial educational approach amidst the global pandemic. With the need for healthcare professionals to quickly adapt to new protocols and guidelines, virtual platforms have become invaluable tools for disseminating knowledge and ensuring patient safety. Through online teaching, healthcare providers can access comprehensive training materials, interactive simulations, and real-time demonstrations, all designed to enhance their understanding and proficiency in intubating Covid-19 patients. These virtual sessions enable the participants to learn from experts in the field, engage in collaborative discussions, and address common challenges encountered during intubation procedures. Online teaching not only offers flexibility in terms of time and location, but also promotes continuous learning and skill development, ultimately improving the patient outcomes in the face of this unprecedented healthcare crisis (25).

The ultimate goal of the study is to enhance online teaching by providing evidence-based recommendations and educational resources that address the complexities of intubation in Covid-19 patients. By improving the understanding of these complications, healthcare professionals and educators can effectively train and prepare healthcare providers to manage intubation procedures in Covid-19 sufferers, leading to improved patient outcomes and overall healthcare quality. As the pandemic has forced many healthcare professionals to shift to online teaching and training, it is crucial to explore the complications of intubation in Covid-19 patients to inform effective online teaching strategies. This literature review aims to explore the existing literature on the

complications of intubation in Covid-19 patients and their implications for online teaching, with the goal of improving patient outcomes and supporting healthcare providers in the face of this global health crisis.

Methods

As to the research objectives of this study, firstly the literature review aimed to clearly state its objectives, which are threefold. The first objective was to identify and understand the complexities associated with intubation in Covid-19 patients. This involves exploring the challenges, risks, and unique considerations that arise when performing intubation procedures on individuals infected with the Covid-19 virus.

The second objective was to assess the effectiveness and adequacy of the existing online teaching methods used for intubation training. This entails examining various instructional approaches, virtual platforms, and educational resources utilized in teaching healthcare professionals the skills required for successful intubation. The goal was to evaluate their strengths, weaknesses, and overall suitability in the context of online learning.

Lastly, the literature review sought to propose strategies for enhancing online teaching methods to effectively address the complexities of intubation. Based on the findings of the previous objectives, this objective aimed to recommend innovative approaches, instructional techniques, and technological advancements that can improve the quality and comprehensiveness of online intubation training. The ultimate aim was to develop practical and efficient solutions that can better prepare healthcare professionals to tackle the challenges posed by intubation in Covid-19 cases.

Study Selection Criteria

The study selection criteria for this research consist of both inclusion and exclusion criteria. The inclusion criteria were the articles published in peer-reviewed journals and academic conferences to

ensure their credibility and adherence to rigorous evaluation processes; the studies published between 2019 and 2023; studies with the focus specifically on the Covid-19 pandemic in order to ensure relevance to the current context; articles written in English to facilitate comprehension and accessibility for the research team; and studies that provide insights into the complexities of intubation in Covid-19 patients or discuss online teaching methods for intubation training. Non-peer-reviewed articles, book chapters, and editorials were excluded to maintain a high standard of quality and reliability.

Data Sources

A variety of data sources were employed for this research. The primary databases used for literature search included PubMed, Scopus, Web of Science, and Google Scholar. These databases are renowned for their comprehensive coverage of scholarly articles and research publications. In addition to these databases, relevant professional association websites were consulted to access resources and guidelines from experts in the field. Moreover, gray literature repositories were considered as an additional source, allowing for the inclusion of non-traditional research outputs such as reports and conference proceedings. By utilizing this diverse range of data sources, the research aimed to gather a wide range of information and perspectives to ensure a comprehensive analysis of the topic at hand.

Search Strategy

To conduct a thorough literature search, we developed a comprehensive search strategy. The strategy involved utilizing a combination of keywords and search terms, including variations and synonyms, to ensure a wide coverage of relevant literature. The key terms included “Covid-19”, “SARS-CoV-2”, “intubation”, “airway management”, “respiratory support”, “online teaching”, “virtual education”, and “simulation-based training.” By incorporating these terms, the search aimed to find the studies and articles

that addressed the complexities of intubation in Covid-19 patients and explored online teaching methods for intubation training. The inclusion of variations and synonyms expanded the search scope, enabling a more comprehensive retrieval of pertinent literature for the research.

Study Selection Process

The study selection process involved an approach to ensure the inclusion of relevant articles while maintaining consistency with the predetermined criteria. Initially, articles were screened based on their titles and abstracts to assess their potential relevance. Subsequently, the full-text articles that passed the initial screening were carefully evaluated against the established inclusion and exclusion criteria. This comprehensive review process was conducted by two independent reviewers who assessed the articles for their alignment with the research objectives. Any discrepancies or disagreements between the reviewers were resolved through discussion and consensus. By employing this rigorous study selection process, the research aimed to ensure the inclusion of high-quality and pertinent articles in the final analysis.

Data Extraction

A standardized data extraction form was developed to facilitate the collection of relevant information from the selected studies. The form ensured consistency in data extraction by capturing key details from each study. This included information such as the author(s), publication year, and study design to provide a clear understanding of the study’s background. Methodological details, including the participant characteristics if applicable, were recorded to gain insights into the approach of the study. The data extraction form also focused on extracting the key findings related to the complexities of intubation in Covid-19 patients, providing a comprehensive overview of the challenges, risks, and unique considerations identified in the literature. Additionally, the form captured details about online teaching methods,

their effectiveness, and any limitations or recommendations provided by the authors. By utilizing this standardized approach, the researchers aimed to gather essential information for further analysis and synthesis.

The utilization of a standardized data extraction form ensured consistency and accuracy in capturing the necessary information from the selected studies. The form facilitated the organization and categorization of the literature by extracting details such as author(s), publication year, and study design. Furthermore, the form allowed for the recording of methodology and participant information, enabling a comprehensive understanding of the research approaches employed. The extraction form also focused on key findings pertaining to the complexities of intubation in Covid-19 patients, shedding light on important insights from the literature. Additionally, by documenting the description and effectiveness of online teaching methods, as well as limitations and recommendations provided by the authors, the data extraction form enabled a comprehensive analysis of the current state of knowledge in this area.

Data Analysis

The data analysis phase of the research

employed thematic analysis as the chosen approach. Thematic analysis involved identifying recurring themes and sub-themes within the extracted data from the selected studies. The data, including key findings, information on online teaching methods, and limitations/recommendations were organized and categorized based on these identified themes. By structuring the data in this way, patterns, similarities, and discrepancies across the studies were examined and analyzed. This process aimed to derive meaningful insights and generate a comprehensive understanding of the complexities of intubation in Covid-19 patients and the effectiveness of online teaching methods for intubation training. The results of the analysis were then interpreted to draw conclusions and contribute to the research objectives (Figure 2).

Results

Complexities Associated with Intubation in Covid-19 Patients

Intubation and being on a ventilator are related but not exactly the same. Intubation is the process of placing an endotracheal tube (ETT) into the trachea. The tube is then connected to a device that delivers the air (26, 27). This device can be a bag that the doctor inflates to get the air into your body,

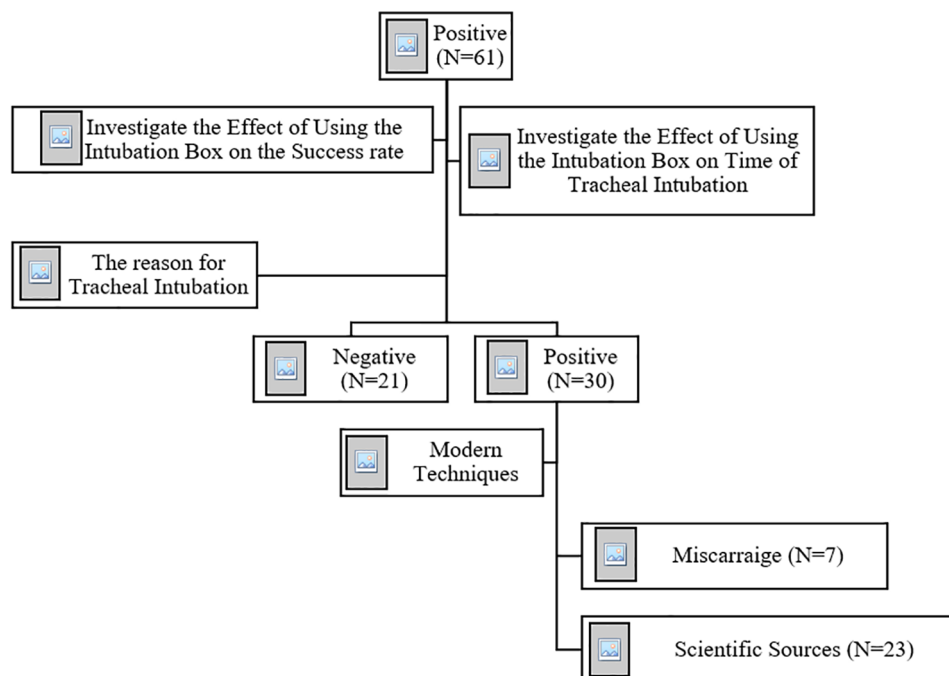


Figure 2: Flow chart of the included subjects

or it can be a ventilator, a device that delivers oxygen to your airways and lungs. Sometimes a ventilator delivers air to the person through a mask instead of a tube. In some cases, doctors decide that intubation is not safe, such as when there is severe trauma to the airway or when there is an obstruction that makes safe placement of the tube impossible. In such cases, doctors may decide to open an airway in the person's throat in the lower part of the neck (28).

The Goals of Repentance

The following can be considered for the purposes of repentance:

- 1- Opening the airway to inject oxygen and anesthesia to the patient;
- 2- Removing the obstruction of the lungs;
- 3- Helping the patient to breathe in case of lung collapse or heart failure;
- 4- Diagnosing airway obstruction by the doctor;
- 5- Avoiding liquid consumption by patients (28).

Specialties related to intubation include Cardiology, neurology, pulmonary medicine, internal medicine, pediatrics, neurology, and traumatology. Intubation varies depending on the purpose and type in the operating room or in the emergency setting. In the operating room or other controlled environments, the doctor uses anesthesia to put the person to sleep. He then places an instrument called a laryngoscope into the person's mouth to insert a flexible tube. If the doctor faces vision problems at the time of diagnosis, he can insert a small camera into the person's body for guidance. In the operating room, doctors often use intubation to help a person under anesthesia. Emergency intubation carries certain risks due to high blood pressure, and for this reason the person may not be as stable as someone in the operating room (29, 30).

Stages of Repentance

Most transplants are done in the hospital. Sometimes EMS treats people outside of the hospital setting. During this process, healthcare providers do the following for intubation: An IV needle is inserted into

the arm. Medicines are given through an IV for pain relief as needed. An oxygen mask is placed over the nose and mouth to give a little more oxygen to the body. In the next step, the mask is removed and the patient's head is tilted back, and the laryngoscope is inserted into the mouth (or sometimes the nose if needed) (30, 31). The device is moved to the back of the mouth and away from the teeth. A tracheostomy is a raised flap of tissue that hangs at the back of the mouth to prevent inflammation of the larynx. A small balloon is inflated around the trachea, holding it in place and allowing all the air in the trachea to reach the lungs. At this time, it is better to remove the laryngoscope. The nurse and team who performed the procedure will test to make sure the tube is in the right place (32).

The Dangers of Repentance

Repentance is a common and generally safe method that can help save lives. Most people recover within a few hours or days, but some rare side effects may occur:

Aspiration: When a person is intubated, they may inhale vomit, blood, or other fluids in their throat after regaining consciousness.

Intra-bronchial intubation: A tracheal tube can be placed in one of the two bronchi, a pair of tubes that connect the trachea to the lungs.

Esophageal intubation: If the tube enters the esophagus (food pipe) instead of the trachea, it can cause brain damage or even death if not diagnosed quickly.

Failure to secure the airway: When intubation is unsuccessful, health care providers may not be able to provide appropriate services to the individual

Infection: People with sinusitis may develop infections such as sinus infections.

Damage: This method can damage the mouth, teeth, tongue, vocal cords or respiratory tract. Injuries can cause bleeding or swelling.

Problems due to anesthesia: Most people recover well after anesthesia, but some of them have trouble waking up and need medical emergencies.

Tension pneumothorax: When the air gets trapped in the chest cavity, it can cause your lungs to collapse (33, 34).

Complications of Tracheal Intubation and Measures to Reduce Complications

Known complications when using a tracheal tube include complications during intubation, complications after intubation, and complications after extubation. Careful and continuous monitoring of the patient during and after intubation can slightly reduce these complications (35).

A- Complications during Endotracheal Intubation

1- Fear: Conscious patients might be afraid of intubation.

Actions: It is better to prepare the patient completely psychologically before the procedure if he is conscious. Explaining other methods of communication and making the news bell available for necessary cases, as well as assuring the patient that experienced personnel will be at his/her bedside whenever necessary, can effectively reduce the patient's anxiety (36, 37).

2- Trauma, laryngospasm and bronchospasm: Failure to fully observe the vocal cords during intubation, inserting the tube with pressure and violence may lead to the above complications.

Actions: Before intubation, the patient's throat and mouth should be completely cleaned of secretions, and the batteries of the laryngoscope should be completely strong and full of light.

3- Cardiac dysrhythmias: The most important dysrhythmia is bradycardia due to stimulation of the vagus nerve.

Actions: Prevention of complications such as low blood pressure.

4- Incorrect placement of the tracheal tube: There is always a possibility of wrong placement of the tracheal tube and its entry into the esophagus during intubation.

Actions: As soon as the tube is inserted, the cuff should be inflated, and then the patient should be given a few manual breaths through

the ambo bag, and while breathing, the tops of the patient's lungs should be checked for the presence of breathing sounds, and if there is no sound, the xiphoid area should be checked for entry. Air into the stomach should be auscultated. If the endotracheal tube is wrongly placed, correct its location immediately (37).

5- Excessive introduction of the tracheal tube: Excessive introduction of the tracheal tube into the patient's trachea, which may be directed into one of the bronchi (usually the right bronchus) causes problems; in such a situation, by filling the cuff of the tracheal tube, the other bronchus is closed and suffer from atelectasis due to lack of ventilation.

Actions: In order to control the replacement site of the end of the endotracheal tube, it is necessary to take a chest X-ray immediately after intubation. Also, bilateral auscultation of the lung sounds every two hours or after any change of position helps the patient (38).

6- Possible vomiting and aspiration: During oral intubation, if the gag reflex is stimulated, there is a possibility of vomiting and aspiration of the stomach contents into the trachea.

Actions: If there is sufficient time, it is better to place NGT before intubation and drain the gastric secretions.

7- Hypoxia due to delay in operation:

Actions: It is better to hyper-oxygenate the patient with 100% oxygen for one to two minutes before intubation. If it drops significantly and the disturbance in SaO₂ symptoms takes more than 30 seconds to intubate the patient or if hemodynamics occurs, the operation should be stopped and the patient should be ventilated with 100% oxygen by ambo bag and mask, and then intubation should be done again.

8- Upper airway trauma: One of the common traumas is injury to the patient's teeth, and bleeding and nasal septum fracture are complications of nasal pressure intubation.

Actions: In order to prevent this injury, care must be taken not to use the patient's upper teeth as a lever to pull up the laryngoscope blade during intubation (39, 40).

B- Complications of Intubation when the Tube Is in Place

1- Tracheal tube obstruction: Due to the accumulation of thick plaque secretions caused by dried secretions, bending and biting of the tube by the patient might happen and cause insufficient ventilation.

Actions: In order to prevent the bending of the tracheal tube, the patient's head should be placed in a natural position and the neck should be prevented from bending.

- The ventilator tubes should be supported by the pillow;
- Airway should be used to prevent gassing;
- over-inflating the cuff should be avoided to prevent herniation of the tracheal tube cuff on the end of the tube;
- Accurate and regular suction is necessary to prevent accumulation of the secretions and plaque formation inside the tracheal tube;
- Adequate humidity of the airways should be maintained;
- Any problems in passing the suction catheter in the tracheal tube should be reported;
- In case of failure to open the airway, you should replace the endotracheal tube in a timely and routine manner (37, 38).

2- Leakage from the cuff: The balloon not being filled after air injection, the patient's ability to speak after the cuff is filled???, and hearing air leakage in the larynx during breathing with positive pressure are symptoms of cuff leakage.

Actions: To avoid the risk of aspiration, the patient should be re-intubated.

3- Damage to the upper airways: Ulcers, necrosis, and narrowing of the trachea occur as a result of excessive pressure of the cuff on the tracheal wall, infection due to inappropriate size of the tracheal tube, and a long period of intubation.

Actions:

- To prevent pressure sores on the side of the lip, the position of the tube inside the mouth should be changed at least once every 24 hours, and a folded gauze should be placed between the tracheal tube and the corner of the lips.

➤ Diluted mouthwash is necessary to prevent the accumulation of oral pathogens in the airway (39, 41).

➤ To prevent abrasion injuries, head movements, especially forward and backward bending, should be done to a minimum.

➤ A suitable size tracheal tube should be used.

➤ To prevent glottis injuries, a tracheostomy tube should be placed after 10 days of intubation (41).

4- Injury to the trachea: Factors affecting the injury of the trachea include infection, duration of intubation, inappropriate size of the tracheal tube, incorrect positioning of the tracheal tube, cuff size, flexibility, shape and pressure inside the cuff, and finally hypotension.

Actions: In order to minimize the pressure of the cuff on the trachea, actions related to airway damage are helpful.

5- Bleeding: Hemorrhage from around the tube and its pulsation is the reason for damage or rupture of the innominate artery by the end of the tracheal tube.

Actions: Correct the position of the tube and use a narrower and shorter tube, and in case of bleeding, immediately inflate the cuff and inform the doctor. The final solution to this problem is surgery (Figure 3) (42).

6- Infection: Due to the elimination of upper airway defense mechanisms, the possibility of infection increases.

Actions:

➤ Airway suction should be performed with a completely sterile method and with a new catheter each time.

➤ The pipes and humidifier and vaporizer tank of the ventilator should be replaced every 24 hours, the water collected in the ventilator pipes should be drained, and care should be taken so that it does not enter the patient's airway (40).

C- Complications After Extubating the Patient

1- Larynx spasm or edema: It is one of the immediate side effects after extubating the patient, which potentially leads to airway obstruction.

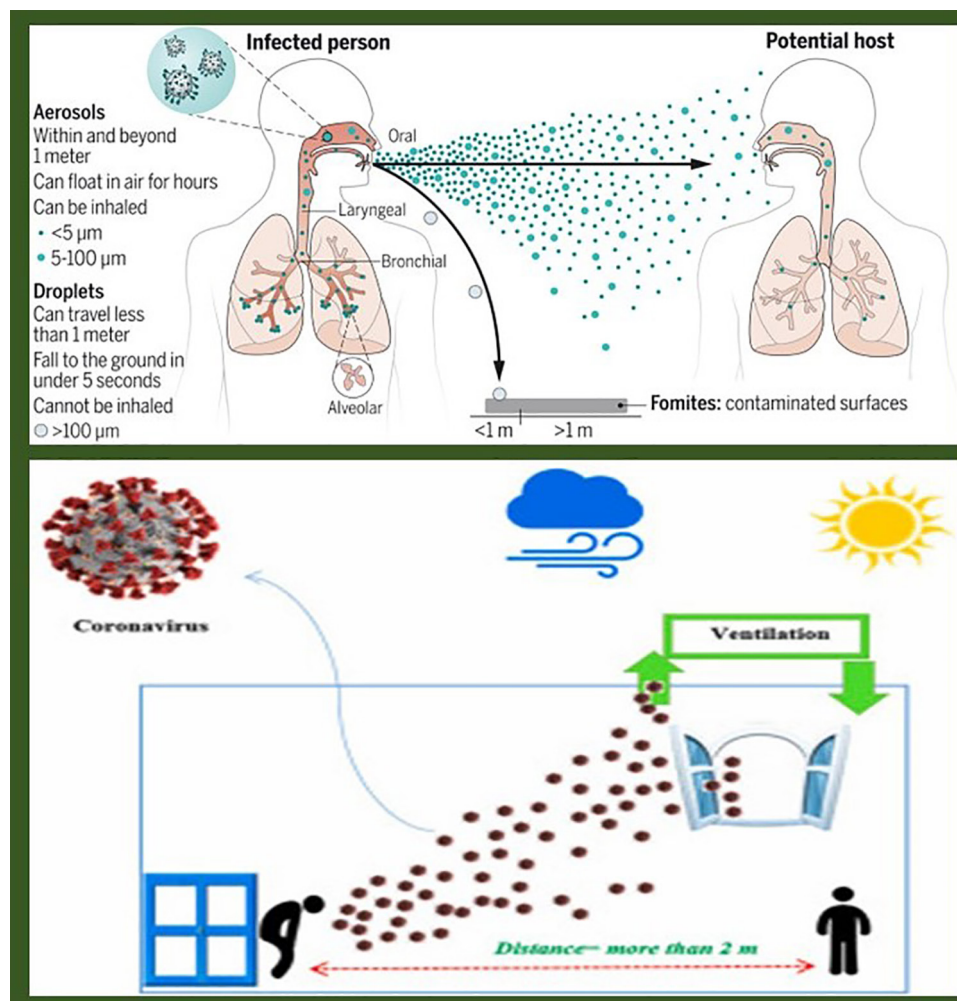


Figure 3: Airborne transmission of SARS-CoV-2 (40, 41)

Actions: The use of hydrocortisone can be effective in reducing laryngeal edema. Otherwise, re-intubation is necessary.

2- Stridor and voice violence: It is temporary and disappears within a week or two.

3- Formation of larynx and trachea granuloma: It causes airway narrowing or obstruction.

Actions: When the patient is intubated, regularly suction the secretions above the cuff so as not to cause chemical inflammation and tissue reaction around the contact area with the tracheal tube.

4- Widening of trachea and tracheomalacia: It happens after long-term intubation.

5- Stenosis of the larynx: Injuries at the level of the glottis and below the glottis are among the most serious intubation injuries.

Actions: This complication can be minimized by choosing the right endotracheal

tube, filling the cuff correctly, shortening the intubation time, preventing infection, and preventing the movement of the tracheal tube

6- Paresis or paralysis of the vocal cords: Damage to the laryngeal nerve may lead to paralysis of the vocal cords.

Actions: Such patients should be monitored for possible aspiration or upper airway obstruction and evaluated for swallowing reflex (Figure 4) (42, 43).

Online Teaching Methods for Intubation Training

The literature review identified several studies that investigated the effectiveness of online teaching for intubation in Covid-19 patients. These studies utilized various online platforms, including video-based modules, virtual simulations, and interactive webinars, to deliver training to healthcare professionals.

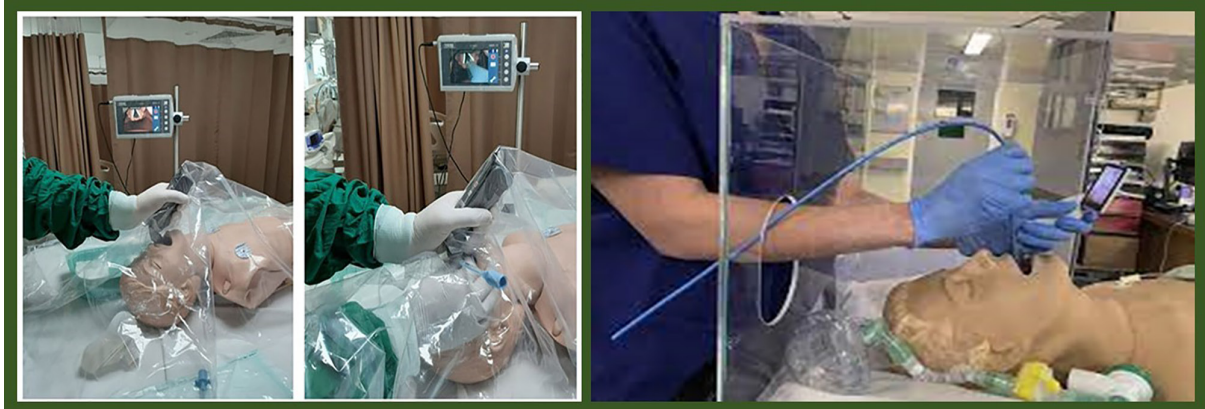


Figure 4: Reducing the risk of spread of Corona virus in intubation with the help of video laryngoscope (43)

The results consistently suggested that online teaching could effectively enhance knowledge acquisition and improve intubation skills among healthcare providers (44).

Knowledge Acquisition: The studies found that online teaching methods were successful in imparting theoretical knowledge related to intubation techniques. Participants who underwent online training demonstrated improved understanding of the anatomical landmarks, equipment usage, and procedural steps involved in intubation. Online modules with interactive elements, such as quizzes and case-based discussions, were particularly effective in reinforcing knowledge retention (45).

Skill Enhancement: Online teaching has also been proved to be beneficial in enhancing intubation skills. Participants reported increased confidence in performing intubation procedures after completing online training programs. The use of virtual simulations allowed for realistic practice scenarios, providing opportunities to refine technical skills, such as laryngoscope manipulation, tube insertion, and cuff inflation. Participants who engaged in simulation-based training demonstrated improved performance in simulated intubation scenarios (46).

Participant Satisfaction: Overall, healthcare professionals expressed high levels of satisfaction with online teaching programs. The flexibility and accessibility offered by online platforms were highly valued, allowing the participants to access training materials at their convenience and pace. Online training

programs also provided opportunities for self-directed learning and enabled the participants to review and revisit the content as needed. The ability to receive immediate feedback through online assessments and instructor-guided discussions further enhanced the participants' satisfaction (47).

Strategies for Enhancing Online Teaching to Address the Complexities of Intubation

Teaching intubation skills through online methods can be difficult due to the hands-on nature of the procedure. However, there are effective strategies that can be employed to enhance the online teaching experience and address the complexities of intubation. Consider the following approaches:

1. **Utilize multimedia resources:** Take advantage of high-quality videos, animations, and simulations to visually demonstrate intubation techniques. These resources provide a clear representation of the procedure and facilitate better understanding for students.

2. **Virtual reality (VR) training:** Explore the use of virtual reality technology to create realistic intubation scenarios. VR offers an immersive learning experience, enabling students to practice intubation techniques in a controlled virtual environment (48).

3. **Live demonstrations:** Conduct live demonstrations of intubation procedures using video conferencing tools. This allows students to observe the technique in real-time and interact by asking questions as the

procedure unfolds.

4. **Case-based learning:** Present the students with realistic case scenarios where intubation may be necessary. Discuss the indications, contraindications, and decision-making process involved in selecting the appropriate intubation technique for each case. Encourage active participation and the sharing of thoughts among the students (46).

5. **Interactive discussions:** Facilitate online discussions and forums where students can ask questions, share experiences, and engage in peer-to-peer learning. Encourage students to discuss challenges they may encounter during intubation and brainstorm strategies to overcome them.

6. **Online simulation platforms:** Explore dedicated online simulation platforms that allow the students to virtually practice intubation. These platforms often provide interactive modules and feedback mechanisms to help the students improve their technique.

7. **Provide self-paced learning resources:** Develop self-paced modules or e-learning courses that cover the theoretical aspects of intubation. Include interactive quizzes, case studies, and knowledge checks to reinforce learning and assess comprehension (46, 45).

8. **Expert guest lectures:** Invite experienced practitioners or experts in the field to deliver guest lectures on specific aspects of intubation. This provides students with insights from professionals who possess extensive hands-on experience and can share practical tips and tricks.

9. **Collaborative projects:** Assign students to work on collaborative projects related to intubation. This could involve researching and presenting specific intubation techniques, discussing case studies, or creating educational resources. Collaboration promotes active learning and helps students develop critical thinking skills.

10. **Feedback and assessment:** Provide timely and constructive feedback on students' performance in virtual intubation simulations or assessments. This feedback helps students understand their strengths and areas for improvement, enabling them to refine their

skills (48, 49) (Table 1).

Discussion

In this literature review, we explored the complexities of intubation in Covid-19 patients and its implications for online teaching.

Identify and Understand the Complexities Associated with Intubation in Covid-19 Patients

Intubation in Covid-19 patients is a complex procedure that can lead to various complications. Studies showed that Covid-19 patients who had undergone endotracheal intubation and tracheostomy during their hospitalization had a high incidence of post-extubating stridor and laryngeal injury (50). Another study compared intubation and airway complications between Covid-19 and non-Covid-19 critically ill subjects and found that Covid-19 subjects were more likely to be intubated for acute respiratory distress (51). Tracheal stenosis is also a complication associated with prolonged intubation in Covid-19 patients (52). Health care personnel who perform endotracheal intubations on Covid-19 patients are at high risk of exposure to and transmission of SARS-CoV-2 (53). Therefore, it is important to identify and understand the complexities associated with intubation in Covid-19 patients to minimize the risk of complications and protect the health care personnel performing the procedure.

Assess the Effectiveness and Adequacy of Existing Online Teaching

Online teaching has become increasingly popular in recent years, and especially during the Covid-19 pandemic. There are several studies that assess the effectiveness and adequacy of the existing online teaching. According to a report by the U.S. Department of Education, online learning can produce learning outcomes equivalent to or better than face-to-face learning (54). Additionally, online courses have increased student retention rates about 25–60% (55). However, the sudden transition to online

Table 1: Summary of the articles

Author, year	Title	Type of study	Research community	Results
Moham-madi et al, 2021 (28)	Invasive Airway "Intubation" in COVID-19 Patients; Statistics, Causes, and Recommendations	Review	COVID-19 Patients	Acute respiratory distress in COVID-19 patients could require endotracheal intubation and mechanical ventilation. Severe respiratory distress, loss of consciousness, and hypoxia had been the most important reasons for intubation. Also, increased levels of C-reactive protein (CRP), ferritin, d-dimer, and lipase in combination with hypoxia are correlated with intubation. Old age, diabetes mellitus, respiratory rate, increased level of CRP, bicarbonate level, and oxygen saturation are the most valuable predictors of the need for mechanical ventilation.
Wali et al, 2020, (31)	Pneumomediastinum following intubation in COVID-19 patients	a case series	Five patients	Although rare, development of pneumomediastinum in COVID-19 patients may be a negative prognostic marker. The combination of alveolar damage and weakness of the membranous wall of the trachea, intubation potentially in emergent scenarios, frequent proning and barotrauma from high ventilator pressures may predispose this patient cohort to severe pneumomediastinum.
Nauka et al, 2020, (38)	Practice, Outcomes, and Complications of Emergent Endotracheal Intubation by Critical Care Practitioners During the COVID-19 Pandemic	Retro-spective study	Patients with COVID-19	Video laryngoscopy and <u>neuromuscular blockade</u> were used increasingly during the COVID-19 pandemic. Despite a higher rate of first-pass success during the pandemic, the incidence of complications associated with the procedure was higher.
Carroll et al, 2010, (39)	Emergent endotracheal intubations in children: Be careful if it's late when you intubate*	Retro-spective cohort study.	137 children	Emergent endotracheal intubations are commonly performed in children, are two times more likely to occur off-hours, and are associated with three times the risk of complications as nonemergent intubations.
Dancy, 2021, (41)	Efficacy of Apneic Oxygenation During Pediatric Endotracheal Intubation Difficult tracheal extubation due to endotracheal tube malfunction: A challenge during the COVID-19 pandemic	Literature review	712 patients	The findings in this study confirm that the practice of AO is not only efficacious in increasing the time until initial desaturation but also reduces the overall incidence of hypoxia during laryngoscopy in children.

Bamgbade, Olumuyiwa, 2021, (42)	Difficult tracheal extubation due to endotracheal tube malfunction: A challenge during the COVID-19 pandemic	Case Report	Two cases of difficult extubation	This case series highlights the risk of COVID-19 virus transmission during difficult extubation. This report describes the preventive and reactive management of difficult extubation.
Gandhi et al, 2020, (46)	Emergency Tracheal Intubation in Patients with COVID-19: Experience from a UK Centre	Official guidance from UK national societies	COVID-19 patients	Findings demonstrate that a consultant-led mobile intubation team can safely perform tracheal intubation in critically ill COVID-19 patients across all clinical areas, aided by thorough preparation and training, despite heightened anxiety levels.
Ferri et al, 2020, (50)	Online Learning and Emergency Remote Teaching: Opportunities and Challenges in Emergency Situations	Qualitative research method	Researchers, professors and enterprises	Based on the lessons learned from this worldwide emergency, challenges and proposals for action to face these same challenges, which should be and sometimes have been implemented, are provided.

learning has posed many challenges to faculty and students, and faculty may not have had adequate time to carefully design online courses to take full advantage of the possibilities of the online format. Therefore, the effectiveness of online teaching depends on the design of the learning environment and the strategies used to support learning. Faculty members need to put in more effort to ensure having interactive online courses (56). In conclusion, while online teaching has its advantages, it requires intentional focus and careful design to be effective and adequate.

Online Intubation Training

Online intubation training has become increasingly popular in recent years, especially due to the Covid-19 pandemic. One study compared the intubation success rate and other skills between junior and senior medical professionals using a high-fidelity simulator. The study found that seniority did not always correlate with simulated intubation performance, indicating that training and experience are crucial factors in successful intubation (57).

While online intubation training courses are available, it is important to note that providers should optimize positioning, pre-oxygenation, equipment, and team preparation

when preparing for endotracheal intubation. In addition, providers should be ready to perform other methods of intubation if the initial attempt is unsuccessful. Simulation-based learning, including simulated discussions and communication with standardized patients, has been found to be effective in higher education. In a simulation study comparing direct laryngoscopy and video laryngoscopy, it was found that experience was a significant predictor of successful intubation (58). In a systematic review and meta-analysis, it was found that experience in pre-hospital endotracheal intubation significantly influenced mortality of patients with severe traumatic brain injury. Studies were classified as “limited experience” if intubation was performed by the personnel who usually have basic skills in this technique and who commonly only infrequently perform intubations in routine practice, while “extended experience” was selected if intubation was performed by pre-hospital emergency physicians or nurses/paramedics with an extended scope of practice and training. Overall, while online intubation training can be a useful tool, it is important to note that training and experience are crucial factors in successful intubation. Providers should also be prepared to perform

other methods of intubation if the initial attempt is unsuccessful (59).

One of the limitations of this study is the potential for publication bias. The literature review conducted for this study only included articles published between January 2018 and September 2022. When limiting the search to this specific time frame, there is a possibility that relevant studies published before or after this period were excluded. This could lead to a biased representation of the available evidence and may overlook important findings or advancements in the field of intubation complications and online teaching strategies. Additionally, the search was limited to specific electronic databases, namely PubMed, Embase, and Scopus, which may not include all relevant studies. The exclusion of studies from other databases or gray literature sources could limit the comprehensiveness of the findings and potentially introduce a bias in the selection of studies.

Conclusion

The bedside screening tests reviewed in this review are not well suited to detect unanticipated difficult airways because they miss a large number of individuals with difficult airways. In this research, it shows the effectiveness of sharing a ventilator between patients with the disease of Covid-19 with the appropriate selection of patients, which can be helpful to the treatment staff and patients in the situation of lack of facilities. The review highlights the potential benefits of online learning for healthcare professionals involved in intubation of Covid-19 patients. When grouping patients for ventilator sharing, it is necessary to compare respiratory parameters between two patients and, if possible, put two patients in the same group. Among patients with severe Covid-19, the use of high-flow oxygen via nasal cannula significantly reduced the need for mechanical ventilator support and the time to clinical recovery compared with conventional low-flow oxygen therapy. In general, in cases where surgery is performed under general anesthesia, gastric

intubation will be necessary. This means that most surgeries require this type of care. Although the constant need for a ventilator is scary, most surgical patients can breathe on their own within a few minutes after the end of the surgery.

Despite the positive outcomes, there are certain limitations associated with online teaching for intubation in Covid-19 patients. The lack of physical hands-on practice and direct supervision inherent in online training may hinder the transfer of skills to real-life scenarios. The absence of tactile feedback and the inability to navigate potential complications in real-time can pose challenges during actual intubation procedures. Therefore, it is essential to supplement online teaching with practical hands-on sessions to bridge this gap.

Authors' Contribution

All authors (KG and KA) have reviewed and revised the manuscript all authors agree on the final version.

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