

Review Article

Pediatric tracheostomy in COVID-19 pandemic: a review

Santosh Kumar Swain^{1*}, Ishwar Chandra Behera², Nishtha Ananda¹

¹Department of Otorhinolaryngology, ²Department of Neuro-Critical Care Unit, IMS and SUM Hospital, Siksha “O” Anusandhan University, K8, Kalinganagar, Bhubaneswar, Odisha, India

Received: 26 December 2020

Accepted: 30 January 2021

*Correspondence:

Dr. Santosh Kumar Swain,

E-mail: santoshvoltaire@yahoo.co.in

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Coronavirus disease 2019 (COVID-19) is a highly contagious infection caused by a novel strain of coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The severity of the COVID-19 infection of the pediatric patient varies broadly between a mild cough and fever to severe form of diseases such as acute respiratory distress syndrome (ARDS) for which some may need intubation and followed by mechanical ventilation through tracheostomy in case of prolonged ventilation. Performing tracheostomy in pediatric patient pose a challenge for health care professional as there is high chance of spread of the disease in COVID-19 pandemic. Surgical tracheostomy is an aerosol generating procedure which causes high chance of spread of infections. There is increasing concern for high transmissibility of the virus to the operating surgeon with their assisting staff and other nearby patients. Pediatric tracheostomy should be performed with close association with pediatric otolaryngologists, anesthesiologists and pediatric intensive care physicians along with adequate personal protective equipment (PPE) for smooth and safe execution of the procedure.

Keywords: COVID-19 infections, SARS-CoV-2, Pediatric tracheostomy, Mechanical ventilation

INTRODUCTION

Tracheostomy is one of the commonest and oldest surgical procedures performed in critically ill patients. Pediatric patients may require tracheostomy for several reasons and children with long standing tracheostomy tube are included in the subgroup at high risk of airway compromise. Children infected with SARS-CoV-2 are often asymptomatic. When the children present with symptoms, they have dry cough, fever, fatigue, nasal congestions and rhinorrhea. Some children may have gastrointestinal symptoms like nausea, vomiting, abdominal discomfort, abdominal pain and diarrhea.¹ So, majority of the pediatric patients have mild clinical presentations with good prognosis. However, in few immunocompromised children, the clinical manifestations may worsen and land in acute respiratory distress and respiratory failure, where they need ventilator support and

later on require tracheostomy for prolonged ventilation.² As there is rapidly increase in COVID-19 patients, it is expected that many infected pediatric patients will require oro-tracheal intubation and prolonged mechanical ventilation. In present scenario, the requirement of the tracheostomy in COVID-19 pediatric patients will be more. So, awareness about the indications, risks and benefits, steps, preventive measures are important for the clinicians in present situations. The pediatric tracheostomy may be associated with higher chances of morbidity and mortality. The chances of complications associated with pediatric tracheostomy are more in comparison to the adult or elderly age group.³ Till date, the profile of the pediatric tracheostomy in the COVID-19 pandemic is not reported adequately in medical literature. There are no much studies done in pediatric tracheostomy in COVID-19 pandemic. This review article aims to discuss about indications, risk versus benefits, surgical steps, complications, post-

tracheostomy care and preventive measures in surgical tracheostomy on pediatric patients in COVID-19 pandemic.

METHODS FOR LITERATURE SEARCH

Research articles regarding managing pediatric tracheostomy in COVID-19 pandemic were searched through a multiple approach. First we conducted an online search of the PubMed, Scopus, Google Scholar and Medline database with the word pediatric tracheostomy, COVID-19 pandemic, mechanical ventilation of pediatric patients and aerosol generating procedure in current COVID-19 pandemic. A search strategy using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines was developed (Figure1). Randomized controlled studies, observational studies, comparative studies, case series and case reports were evaluated for the eligibility. This paper focuses only on the pediatric tracheostomy in COVID-19 pandemic. The search articles of adult patients with tracheostomy were excluded. Review articles with no primary research data were also excluded. The published articles were identified by this search method and other articles were identified manually from the citations. This review article reviews the epidemiology, indications, surgical steps of pediatric tracheostomy, post-tracheostomy care and preventive measures in COVID-19 pandemic. This review article will provide awareness among the clinicians, pediatrician, otolaryngologists, anesthesiologists, intensivists and nursing staffs for performing the tracheostomy at the intensive care unit (ICU) or operating room (OR) with proper safety to the health care professionals and other patients.

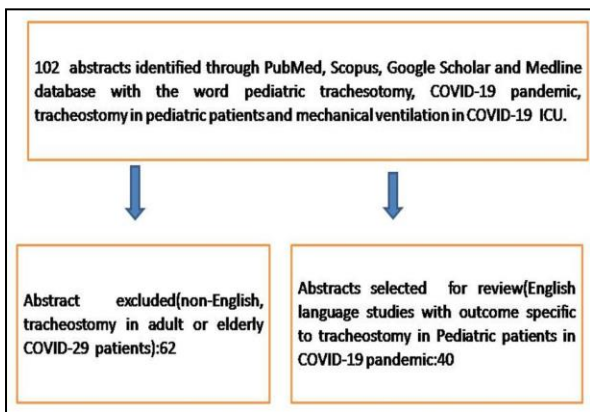


Figure 1: Methods for literature search.

EPIDEMIOLOGY

The COVID-19 was first documented in Wuhan, China in December and rapidly spread all over world.² COVID-19 was announced as a pandemic on March 11th 2020 by the World Health Organization (WHO).⁴ By 27th February, 2020, more than 82,000 COVID-19 positive cases and more than 2800 deaths have been reported of which 95%

of the cases and 97% of deaths were in China.⁵ By the march 26th, 2020, there were 462684 cases of the COVID-19 reported in 199 countries.⁶ At the time of drafting the manuscript i.e. 4th October 2020, more than one million people were died worldwide due to COVID-19 infection. In hospital setting, patients with respiratory failure often need orotracheal intubation and changed to tracheostomy in case of prolonged ventilation. In one study, 6.30% patients need tracheostomy during the COVID-19 outbreak.⁷ Study showing 7.3 to 32% COVID-19 patients progress to severe respiratory failure, where patient may subsequently need tracheostomy for different reasons.^{8,9} Tracheostomy is usually performed for prolonged ventilation in critically ill children. However, in context to COVID-19 pediatric patients, the tracheostomy particularly in pediatric patients pose a challenge to the clinicians because of its poor prognosis and risk of transmission of infections to others.

COVID-19 VIRUS

The coronaviruses belong to a family of the respiratory viruses which frequently cause common cold, second to the rhinovirus. Few decades back, these viruses were associated with severe outbreaks such as severe acute respiratory syndrome (SARS) in 2012 and the middle respiratory syndrome (MERS) in 2012.¹⁰ In late December 2019, a novel strain of coronavirus, called SARS-CoV-2 was responsible for coronavirus disease 2019 (COVID-19) at Hubei, China. SARS-CoV-2 is an encapsulated or enveloped positive strand RNA virus (Figure 2) which can be classified into 4 genera such as alpha, beta, delta and gamma.

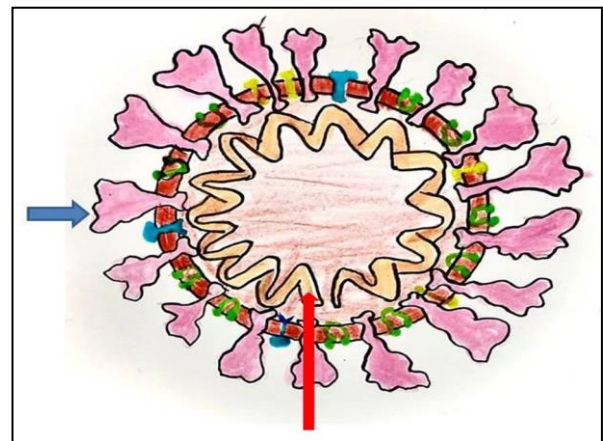


Figure 2: Structure of the COVID-19 virus (blue arrow is spike protein over lipid membrane, red arrow indicates RNA).

Out of these 4 types, alpha and beta are known to infect human beings.⁹ The size of the corona virus is ranging from 60 nm to 140 nm with spike like projection from the surface as a crown like appearance under electron microscope, so the name corona virus.¹¹ The spikes over surface of the virus is made up of glycoprotein which act as critical for binding to the host cell receptors and play a

vital role in severity of the infections of the host.⁹ The most of the human receptors for glycoprotein of this virus, human angiotensin converting enzyme 2 (ACE2) are found mainly in the lower respiratory tract rather than upper respiratory tract. As scarcity of receptors in the upper airway, the clinical symptoms related to upper airway is usually less. The incubation period of SARS-CoV-2 ranges from 1 to 14 days with a median of 5-6 days. Although currently study documents that the incubation period may extend to 24 days.¹² A longer incubation period has implication in quarantine policies and prevention of the spread of the infection. This virus usually transmitted via droplets but also it is seen in blood and stool, so raising question regarding mode of transmission.¹³



Figure 3: Surgeon wearing PPE before performing pediatric tracheostomy.

TRANSMISSION OF COVID-19 INFECTIONS

The surgical tracheostomy is considered as aerosol generating procedure (AGP). There is high chance of exposure of the secretions from the airway to the surgeon and assisting health care professionals.¹⁴ The novel SARS-CoV-2 virus is usually transmitted by respiratory droplets or contact with infected person. Any procedures dealing with larynx, trachea, nose, nasopharynx and oral cavity are prone for transmission of the infections. The common symptoms of COVID-19 pediatric patients are dry cough, fever, fatigue and dyspnea. Asymptomatic COVID-19 pediatric patients are considered as silent carriers in current pandemic. Sometimes patients only present with loss of smell and taste. The infected pediatric patients are usually asymptomatic and some of them present with fever, dry cough, fatigue and nasal symptoms like nasal discharge and nasal block. The health care professionals should aware about the common to uncommon symptoms and also silent carriers, so that it is possible to prevent the

transmission of the infections to the health care workers and other patients during any procedures.

INDICATIONS OF PEDIATRIC TRACHEOSTOMY

Pediatric patient with orotracheal intubation in COVID-19 pandemic can be suggested for tracheostomy after one week; however tracheostomy can be avoided or delayed even beyond two weeks because of the high chance of the infections during the procedure and subsequent tracheostomy care.¹⁵ In current global COVID-19 pandemic, acute respiratory distress syndrome and respiratory failure require ventilation and tracheostomy for prolonged ventilation. When the acute phase of infection is subsided or the likelihood of the recovery of infection is high, tracheostomy can be done for less likelihood of infection transmission. Early tracheostomy should be avoided in case of COVID-19 patients because of the higher viral load. Early tracheostomy is not related to the improved mortality or less ICU stay.¹⁶ As the surgical/open tracheostomy is an aerosol generating procedure (AGP) and has a high risk for contamination through exposing the airway secretions to health care staffs, so this surgical procedure should need a through plan and proper execution to ensure the safety of the staff and patient.¹⁷ Early tracheostomy is usually avoided in COVID-19 patients because of the increased viral load. However, early tracheostomy is also not associated with lowered mortality or reduced to the stay period at the ICU.¹⁸

SURGICAL STEPS OF PEDIATRIC TRACHEOSTOMY

The pediatric tracheostomy should be performed with wearing adequate PPE by health care professionals (Fig.3). All the tracheostomies are usually done after seven days with ventilators. In all the cases of the elective tracheostomy, the cuffed and non-fenestrated tracheostomy tubes are used for limiting the diffusion of the virus. Before performing surgical tracheostomy on COVID-19 pediatric patients, adequate sedation was given to paralyze the patient for eliminating the risk of coughing during the surgery.² The pediatric patient should be fully paralyzed during the procedure. The closed suction system should be attached to the endotracheal tube before the starting of the surgery. Before preparing the child, the intensivist should do suction of the endotracheal tube again along suctioning the subglottic port for confirming the adequate relaxations of the muscles. The endotracheal tube is usually secured with ties for long period before performing the tracheostomy, so this must be removed prior to the procedure and places for easy release of the endotracheal tube tie. The endotracheal tube and oral cavity must be draped over and only accessible to intensivist for maneuvering at the time of the tracheostomy. Initial advancement of the endotracheal tube should be done prior to make a window on the anterior wall of the trachea. Ventilation is ceased before inserting the tracheostomy tube into the trachea. Before inserting the

tracheostomy the cuff should be checked for any leak. All efforts are made for not piercing the cuff of the tracheostomy tube during the surgical procedure. All the surgeries are performed by senior consultant surgeon, a scrub nurse and with presence of one intensivist/anesthetist with adequate PPE to avoid transmission of the infections and also to complete the surgery in less time at the uncomfortable ICU setting.

OPERATING ROOM/ICU

The place of the tracheostomy must be designated with negative pressure.¹⁹ The reverse laminar flow around the operating table is estimated to exchange 90% of the air (expelling the generated aerosol) in six minutes.¹⁹ The unprotected health care professionals should not be

allowed to enter the site of the tracheostomy as this surgery is considered as high aerosol generating procedure. The otolaryngologists and assisting personnel must wear appropriate PPE. The team for tracheostomy includes consultant surgeon, two experienced assistant, a scrub nurse and floor nurse. Different case series for surgical tracheostomies were performed at the time of COVID-19 pandemic with preventive measures (Table 1).^{20,7,21} If pediatric tracheostomy is performed at the operating room, the anesthetic machine, operating table and operating tables should be checked in advance to confirm the proper functioning. The emergency tracheostomy instruments should be properly identified and ready before performing the procedure. The minimum PPE for health care workers for performing an open tracheostomy include FFP3 face mask with confirmed seal, goggles, surgical hood or visor and double gloves.

Table 1: Different case series of open tracheostomies done at the time of COVID-19 pandemic.

Parameters	Wei et al ²⁰	Chee et al ⁷	Tien et al ²¹
Hospital	Queen Mary Hospital, Hong Kong SAR, China	Tan Tock Seng Hospital, Singapore	Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
Number of tracheostomies done	3	15	3
Barrier precautions at time of surgery	Standard PPE, shoe covers, face shield, goggles	Standard PPE, Shoe covers, powered air-purifying respirator system	Standard PPE, Stryker T4 protection system
Setting	Negative pressure room in ICU or OR	Negative pressure room in ICU	Negative pressure room in ICU
Intraoperative steps to minimize aerosolization	Complete paralysis of patient, mechanical ventilation stopped before tracheostomy, no suction used during procedure, diathermy avoided as much possible	Complete paralysis of the patient, mechanical ventilation stopped before tracheostomy, limited suction used during procedure, no specific avoidance of diathermy other than during tracheostomy	Complete paralysis of the patient, mechanical ventilation stopped before tracheostomy, no suction used once trachea opened, diathermy avoided as much as possible
Surgical team	Single surgeon, one intensive care specialist, one standby medical or nursing staff	An experienced surgeon, an experienced anesthesiologist, one scrub nurse and one surgical assistant	Senior attending trauma surgeon, most senior surgical staff member available, attending ICU anesthesiologist and no circulating nurse or scrub nurse.

BENEFITS VERSUS RISK OF TRACHEOSTOMY AT ICU

Study of critically ill COVID-19 pediatric patients reveal that early tracheostomy (within ten days of intubation) is associated with longer ventilator free days, lesser ICU

stays, lesser duration of sedation period and lower mortality rates, although other study document that timing of the tracheostomy does not affect the clinical outcomes.^{17,18} In another study, approximately 66.7% of the patient those underwent tracheostomy did not get the clinical benefit after the tracheostomy.²² Another report from China is also against the positive result for

tracheostomy.²³ There is also another report from SARS treatment suggest that tracheostomy was not associated the significant better outcome.²⁴ Sometimes the tracheostomy is associated with potential complication such as bleeding from trachea. Without doing proper treatment for this infection, the mortality rate goes to severe acute respiratory distress syndrome (ARDS) is very high as around 70%, which goes against for performing the tracheostomy on patients with COVID-19 related ARDS.²⁵ These clinical experience from China suggests that prolonged intubation should not on its own be an indication for doing tracheostomy in COVID-19 patients, as there are risk for patients and health care providers likely shows any marginal benefits in this pandemic. Rather the procedure like tracheostomy should only be done in specific condition such as airway obstruction where the successful extubation is compromised or certain situation where tracheostomy placement has positive impact on patient's potential for successful weaning of the ventilatory support. So, it needs careful consideration when the health resources like ventilators are in limited supply in present COVID-10 pandemic. Agreement with current recommendations by ENT UK, clinicians should believe the situations and evaluations by multidisciplinary fashion like consensus among the specialists for clinical benefit after tracheostomy as weighed against the risk of this procedure is agreed upon before doing this procedure.²⁶

POST-TRACHEOSTOMY CARE

Care giver for post-tracheostomy period should ensure all equipments; particularly the suction probe should be ready. During change of tracheostomy tube, abundant spray of 5% lidocaine to the tracheostomy tube should be done for avoiding the cough and contamination of infections to care givers and other nearby persons. If the pediatric patient is ventilated through tracheostomy tube, the intensivist is asked to sedate the patient to reduce the coughing at the time of changing the cannula. Any materials that have been in contact with suction cannula, tracheostomy tube or trachea or stoma during the post-tracheostomy care must be eliminate via the infectious waste circuit. To stop the risks of contamination of tracheostomy patient's environment, tracheostomy tube should be ideally connected to a heat and moisture exchange (HME) filter and covered by a surgical mask.²⁷

PERSONAL PROTECTION EQUIPMENT (PPE) DURING PEDIATRIC TRACHEOSTOMY

The surgeon and assisting health care professionals should remove the bracelets and other jewelry before scrubbing for the tracheostomy. The surgeon and assisting staff should wear adequate PPE with FFP3 or N95 mask, head shield and goggles. The double gown is preferred along with gloves during surgical tracheostomy. The protection of the head with a hood cap is better than a simple cap in order to prevent any skin exposure. A full face shield/visor or airtight protective glasses are helpful for preventing the

contamination to the health care professionals. The head light should be covered by a head cap. An impermeable protective apron or an overcoat must be worn under the surgical gown as it is not sterile. The surgical team for the pediatric tracheostomy must ensure all the required equipments such as suction catheter, cannula and all surgical instruments required for surgery along with cuffed appropriate size for pediatric tracheostomy tube. The use of the electrocoagulation should be minimized as it can produce the aerosolization of the virus once the trachea is open to outside.²⁸ A sterile transparent interface between the surgeon and patient can be used for restricting the risk of contamination.

COMPLICATIONS AND PROGNOSIS OF PEDIATRIC TRACHEOSTOMY

There are certain complications associated pediatric tracheostomies. These complications are classified into peri-operative, early and late postoperative complication. The complications those are occurring in first post-operative week is called as early complication and those are occurring after the first week is called as late complications. Some patients with tracheostomy during COVID-19 pandemic may develop complications like ulcers in the pharynx and bleeding from the stoma or tracheostomy tube which need further care by Otolaryngologists. Many COVID-19 patients receive high dose of heparin infusion, so there is high chance of bleeding during the tracheostomy. The crust formation inside the tracheostomy tube can be reduced by doing humidification through the tracheostomy tube. Clinician should carefully judge the selection of the proper method of the humidification and a heat moisture exchanger (HME) which represents an alternate to the wet circuit and may minimize the aerosols generation. Nebulizers can be avoided and the spacers with a metered dose inhaler which usually give an alternative technique for medication delivery to the respiratory airway. Unlike to the adult patients, pediatric tracheostomy tube has no inner cannula for removal of the crusts, so without doing humidification are likely to cause blockage of the tracheostomy tube.²⁹ The blocked tracheostomy tube may disrupt the circuit at the time of the emergency and increases the chances of aerosol spread.³⁰ Most of the COVID-19 patients in ICU receive high dose of heparin infusion, so there is increased chance of bleeding during tracheostomy.¹⁷

PREVENTIVE MEASURES

Presently SARS-CoV-2 infections have no vaccine for prevention. Tracheostomy and post-tracheostomy care are considered as a high risk aerosol generating procedures. There is high chance of contamination of health care workers by COVID-19 infections during performing tracheostomy and post-tracheostomy care. There are high chances of transmission of infections among health care workers, so the use of personal protective equipment (PPE) including eye protection is an important in current COVID-19 pandemic. Health care workers like frontliners

wear gowns, gloves and N95 mask with face shield and or goggles. The ventilation should be optimized during the time of tracheostomy at intensive care unit or operating room for limiting the patient oxygen desaturation.³¹ The tracheostomy on the pediatric patient under local anesthesia should not be advisable.²⁸ Drug assisted neuromuscular blockage should be advised for reducing the cough at the time of tracheostomy tube placement. There should be minimum use of electrocoagulation during tracheostomy as it generates aerosolization of the virus particularly when the trachea is open. It is advised to inject 5 cc of lidocaine 5% intra-tracheally via the tracheal wall before making opening on the trachea to reduce the cough reflex. If possible, a sterile transparent interface should be used between the patient and the surgeon in order to prevent the risk of contamination. The ventilation should be stopped just before the opening made on the trachea.² Once the opening is made on trachea, the tracheostomy tube is immediately inserted and ventilation of the pediatric patient is resumed. If the patient needs ventilation in prone position, the tracheostomy tube must be fixed to the skin. An experience surgical team is required to secure and accelerate the tracheostomy for reducing the risk of contamination.

CONCLUSION

Currently COVID-19 infections are a real challenge for medical community. In current global COVID-19 pandemic, acute respiratory distress syndrome and respiratory failure in pediatric age group require mechanical ventilation. Prolonged ventilation is the common indications for tracheostomy at COVID-19 ICU. Tracheostomy in pediatric patients is relatively challenging surgical procedure. The commonest indication for pediatric tracheostomy in COVID-19 pediatric patient is prolonged ventilation. Tracheostomy is a high risk aerosol generating procedure because of the exposure to droplets and aerosols leakage which is infected with SARS-CoV-2 at time of performing this surgery. An increasing number of tracheostomy is expected because of the increase number of the COVID-19 pediatric patients globally with acute respiratory distress. The otolaryngologists and intensivist should pay meticulous attention for infection control to reduce the cross-contamination and their own risk for contracting the infection. Pediatric tracheostomy should be performed with adequate PPE for reducing the droplets and aerosols exposure to the surgeon and other health care workers.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

REFERENCES

- Swain SK, Acharya S, Sahajan N. Otorhinolaryngological manifestations in COVID-19 infections: An early indicator for isolating the positive cases. *Journal of the Scientific Society.* 2020;47(2):63.
- Swain SK, Das S, Padhy RN. Performing tracheostomy in intensive care unit-A challenge during COVID-19 pandemic. *Siriraj Medical Journal.* 2020;72(5):436-42.
- Özmen S, Özmen Ö. Pediatric tracheostomies: a 37-year experience in 282 children. *Int J Pediatr Otorhinolaryngol.* 2009;73:959-61.
- Guo YR, Cao QD, Hong ZS, Tan YY, Chen SD, Jin HJ, et al. The origin, transmission and clinical therapies on coronavirus disease 2019(COVID-19) outbreak-an update on the status. *Mil Med Res.* 2020;7(1):11.
- Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *Jama.* 2020;323(13):1239-42.
- Coronavirus disease 2019 (COVID-19) Situation Report –66. World Health Organization. March 26, 2020 https://www.who.int/docs/defaultsource/coronaviruse/situation-reports/20200326-sitrep-66-covid-19.pdf?sfvrsn=81b94e61_2. Last accessed on 01 November, 2020.
- Chee VW, Khoo ML, Lee SF, Lai YC, Chin NM. Infection control measures for operative procedures in severe acute respiratory syndrome-related patients. *Anesthesiology.* 2004;100(6):1394-98.
- Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. *JAMA.* 2020;323(11):1061-9.
- Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet.* 2020;395(10223):497-506.
- Bermingham A, Chand MA, Brown CS, Aarons E, Tong C, Langrish C, et al. Severe respiratory illness caused by a novel coronavirus, in a patient transferred to the United Kingdom from the Middle East, September 2012. *Eurosurveillance.* 2012;17(40):20290.
- Richman DD, Whitley RJ, Hayden FG. *Clinical Virology*, 4th ed. Washington. ASM Press; 2016.
- Bai Y, Yao L, Wei T, Tian F, Jin DY, Chen L, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA.* 2020.
- Zhang W, Du RH, Li B. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. *Emerg Microbes Infect.* 2020;9(1):386-89.
- Swain SK, Agrawala R. Mastoid surgery: a high-risk aerosol generating surgical procedure in COVID-19 pandemic. *International Journal of Otorhinolaryngology and Head and Neck Surgery.* 2020;6(10):1941.
- Framework for open tracheostomy in Covid-19 patients. <https://www.entuk.org/>

- sites/default/files/files/COVID%20tracheostomy%20guidance_compressed.pdf. Last accessed on 15 April, 2020.
16. Young D, Harrison DA, Cuthbertson BH, Rowan K. TracMan Collaborators: Effect of early vs late tracheostomy placement on survival in patients receiving mechanical ventilation: The TracMan randomized trial. *JAMA.* 2013;309(20):2121-9.
 17. Hosokawa K, Nishimura M, Egi M, Vincent JL. Timing of tracheotomy in ICU patients: a systematic review of randomized controlled trials. *Critical care.* 2015;19:424.
 18. Wang F, Wu Y, Bo L, Lou J, Zhu J, Chen F et al. The timing of tracheotomy in critically ill patients undergoing mechanical ventilation: a systematic review and meta-analysis of randomized controlled trials. *Chest.* 2011;140(6):1456-65.
 19. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalised patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA.* 2020;323:1061-9.
 20. Wei WI, Tuen HH, Ng RW, Lam LK. Safe tracheostomy for patients with severe acute respiratory syndrome. *The Laryngoscope.* 2003;113(10):1777-79.
 21. Tien HC, Chughtai T, Jogeklar A, Cooper AB, Brennehan F. Elective and emergency surgery in (SARS). *Can J Surg.* 2005;48(1):71-4.
 22. Cui Chong, Yao Qi, Zhang Di, Zhao Yu, Zhang Kun, Nisenbaum Eric. Approaching Otolaryngology Patients during the COVID-19 Pandemic. *Otolaryngology and Head Neck surgery.* 2020;163(1):121-31.
 23. Yu S, Yujuan H, Hongjun X. Recommendations for diagnosis and treatment of emergency diseases in ENT surgery during the prevention and control of new coronavirus. *Chin J Otorhinolaryngol Head Neck Surg.* 2020;4:322-5.
 24. Liu Y, Sun W, Li J, Chen L, Wang Y, Zhang L, et al. Clinical features and progression of acute respiratory distress syndrome in coronavirus disease 2019. *MedRxiv.* 2020.
 25. Guidance for Surgical Tracheostomy and Tracheostomy Tube Change during the COVID-19 Pandemic. 2020. <https://www.entuk.org/tracheostomy-guidance-during-covid-19-pandemic>. Last accessed on 01 November, 2020.
 26. Kligerman MP, Vukkadala N, Tsang RK, Sunwoo JB, Holsinger FC, Chan JY, et al. Managing head and neck cancer patients with tracheostomy or laryngectomy during the COVID-19 pandemic. *Head & Neck.* 2020;42(6):1209.
 27. Swain SK, Behera IC. Managing pediatric otorhinolaryngology patients in coronavirus disease-19 pandemic-A real challenging to the clinicians. *Indian Journal of Child Health.* 2020;7(9):1-4.
 28. Swain SK, Sahu MC, Choudhury J, Bhattacharyya B. Tracheostomy among paediatric patients: Our experiences at a tertiary care teaching hospital in Eastern India. *Pediatrics Polska-Polish Journal of Paediatrics.* 2018;93(4):312-7.
 29. Zhejiang University School of Medicine: Handbook of COVID-19 Pre-ventilation and Treatment. 2020.
 30. Foster P, Cheung T, Craft P. Novel approach to reduce transmission of COVID-19 during tracheostomy. *Journal of American College of Surgeons.* 2020; 230(6):1102-104.
 31. Swain SK, Behera IC, Sahu MC. Bedside open tracheostomy at intensive care unit-our experiences of 1000 cases at a tertiary care teaching hospital of eastern India. *Egyptian Journal of Ear, Nose, Throat and Allied Sciences.* 2017;18(1):49-53.

Cite this article as: Swain SK, Behera IC, Ananda N. Pediatric tracheostomy in COVID-19 pandemic: a review. *Int J Contemp Pediatr* 2021;8:602-8.