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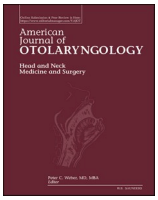

COVID-19 survivorship: How otolaryngologist-head and neck surgeons can restore quality of life after critical illness

Vinciya Pandian [a,b], Martin B. Brodsky [b,c,d], Emily P. Brigham [c], Ann M. Parker [b,c], Alexander T. Hillel [e], Joshua M. Levy [f], Christopher H. Rassekh [g], Anil K. Lalwani [h], Dale M. Needham [a,b,c,d], Michael J. Brenner [i,j,*]

[a] Department of Nursing Faculty, Johns Hopkins University, Baltimore, MD, United States
[b] Outcomes After Critical Illness and Surgery (OACIS) Research Group, Johns Hopkins University, Baltimore, MD, United States
[c] Division of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, MD, United States
[d] Department of Physical and Rehabilitation, Johns Hopkins University, Baltimore, MD, United States
[e] Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins University, Baltimore, MD, United States
[f] Department of Otolaryngology-Head and Neck Surgery, Emory University, Atlanta, GA, United States
[g] Department of Otolaryngology-Head and Neck Surgery, University of Pennsylvania, Philadelphia, PA, United States
[h] Department of Otolaryngology-Head and Neck Surgery, Columbia University Vagelos College of Physicians and Surgeons, New York-Presbyterian/Columbia University, NY, New York, United States
[i] Department of Otolaryngology-Head & Neck Surgery, University of Michigan Medical Center, Ann Arbor, MI, United States
[j] Global Tracheostomy Collaborative, Raleigh, NC, United States

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ABSTRACT

Mortality from COVID-19 has obscured a subtler crisis – the swelling ranks of COVID-19 survivors. After critical illness, patients often suffer post-intensive care syndrome (PICS), which encompasses physical, cognitive, and/or mental health impairments that are often long-lasting barriers to resuming a meaningful life. Some deficits after COVID-19 critical illness will require otolaryngologic expertise for years after hospital discharge. There are roles for all subspecialties in preventing, diagnosing, or treating sequelae of COVID-19. Otolaryngologist leadership in multidisciplinary efforts ensures coordinated care. Timely tracheostomy, when indicated, may shorten the course of intensive care unit stay and thereby potentially reduce the impairments associated with PICS. Otolaryngologists can provide expertise in olfactory disorders; thrombotic sequelae of hearing loss and vertigo; and laryngotracheal injuries that impair speech, voice, swallowing, communication, and breathing. In the aftermath of severe COVID-19, otolaryngologists are poised to lead efforts in early identification and intervention for impairments affecting patients' quality of life.

* Corresponding author at: Department of Otolaryngology-Head & Neck Surgery, University of Michigan Medical Center, 1500 East Medical Center Drive SPC 5312, 1904 Taubman Center, Ann Arbor, MI 48109-5312, United States.
E-mail addresses: vpandia1@jhu.edu (V. Pandian), mbbrodsky@jhmi.edu (M.B. Brodsky), epfeil1@jhmi.edu (E.P. Brigham), aparke36@jhu.edu (A.M. Parker), ahillel@jhmi.edu (A.T. Hillel), joshua.levy2@emory.edu (J.M. Levy), Christopher.Rassekh@pennmedicine.upenn.edu (C.H. Rassekh), akl2144@cumc.columbia.edu (A.K. Lalwani), dale.needham@jhmi.edu (D.M. Needham), mbren@med.umich.edu (M.J. Brenner).

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1. Introduction

December 7, 1941, "A day that will live in infamy" marked the attack on Pearl Harbor – a day of massive, catastrophic loss of life. December 2020 witnessed similar loss of life with *each day* of the coronavirus disease-2019 (COVID-19) pandemic. This mortality represents the tip of the larger iceberg of COVID-19 survivorship. Even with the promise of widespread vaccination, the aftermath of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection can be crippling, particularly for those who have a severe course of illness requiring mechanical ventilation in an intensive care unit (ICU) [1]. Otolaryngologists play important roles in COVID-19 survivor care and have engaged with the pandemic response from investigating early symptoms of olfactory and gustatory loss to decisions around tracheostomy, airway interventions, and rehabilitation [2].

2. Post-intensive care syndrome (PICS)

To provide optimal care for patients, Otolaryngologists need to understand COVID-19 survivorship after critical illness. PICS encompasses a spectrum of physical, cognitive, and/or mental health impairments experienced by patients after ICU stay that can be long-lasting barriers to resuming a meaningful life [3]. For some post-ICU impairments, a longer duration of critical illness is associated with greater impairment [4]. Timing of tracheostomy is therefore a key consideration [5]. Over 80% of patients requiring mechanical ventilation manifest residual impairments (Fig. 1), many directly relevant to otolaryngology and potentially lingering for years after hospital discharge (Fig. 2) [6].

Patients who survive ICU stays often face profound debilitation–with muscle weakness, memory loss, anxiety, depression, and post-traumatic stress disorder (PTSD). Specifically, prolonged ventilation promotes patient frailty, which can require a very long period of rehabilitation. Laryngotracheal injury impairs voice, swallowing, and breathing. A year after ICU discharge, 34% of patients over age 50 have cognitive impairments similar to a moderate traumatic brain injury; a quarter demonstrate cognitive decline similar to mild Alzheimer's disease [7]. The joy that families experience when their loved ones survive is often replaced by grim realization that the road to recovery is long and arduous. Otolaryngologists are capable of providing timely diagnosis, education to patients and families, and specialized interventions (Tables 1 & 2).

3. Airway injury

There is growing awareness of device-related pressure injuries and trauma that may arise in COVID-19 patients, resulting in lasting functional impairment. Laryngotracheal injuries include posterior glottic stenosis with resultant vocal cord immobility, vocal fold edema, or posterior glottic ulcerations. More distally, cuff injury may cause subglottic and/or tracheal stenosis. In one study of COVID-19 patients intubated more than 14 days, 14 of 30 (47%) patients had transmural tracheal erosion resulting in pneumomediastinum, pneumothorax, and tracheoesophageal fistulas [8]. Laryngeal injury is linked to duration of intubation [9], size of endotracheal tube, and difficulties with endotracheal tube insertion. Intubation can be more challenging due to reduced visualization or personal protective equipment that impedes communication. Otolaryngologist input into optimal tracheostomy timing and multidisciplinary care may decrease laryngeal injuries and expedite both early diagnosis and intervention [5].

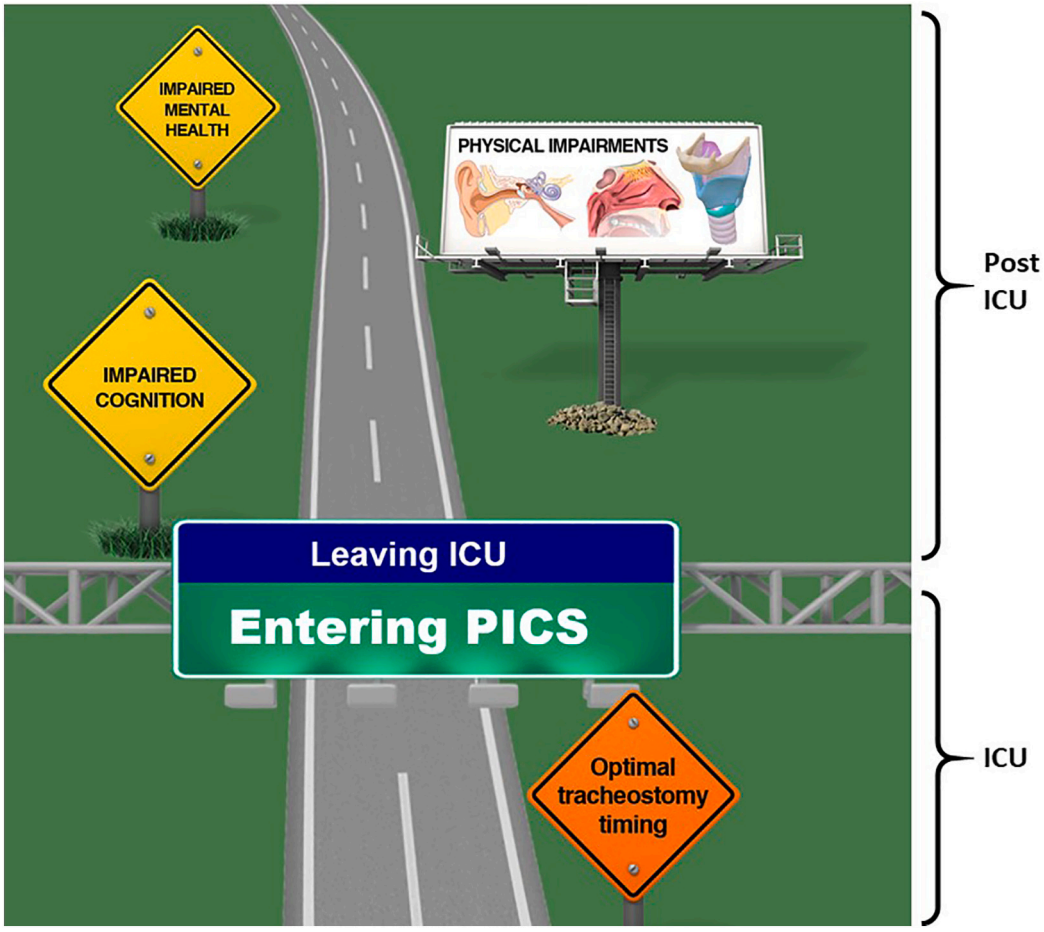

Fig. 1. Key reminders for Otolaryngologists-Head and Neck Surgeons along the road to intensive care recovery. Offering tracheostomy to avoid prolonged intubation may mitigate the severity of PICS. After intensive care unit stay, patients will often encounter complex cognitive, mental health, and physical impairments, many related to otolaryngology expertise.
Abbreviations: PICS, post-intensive care syndrome; ICU, intensive care unit.
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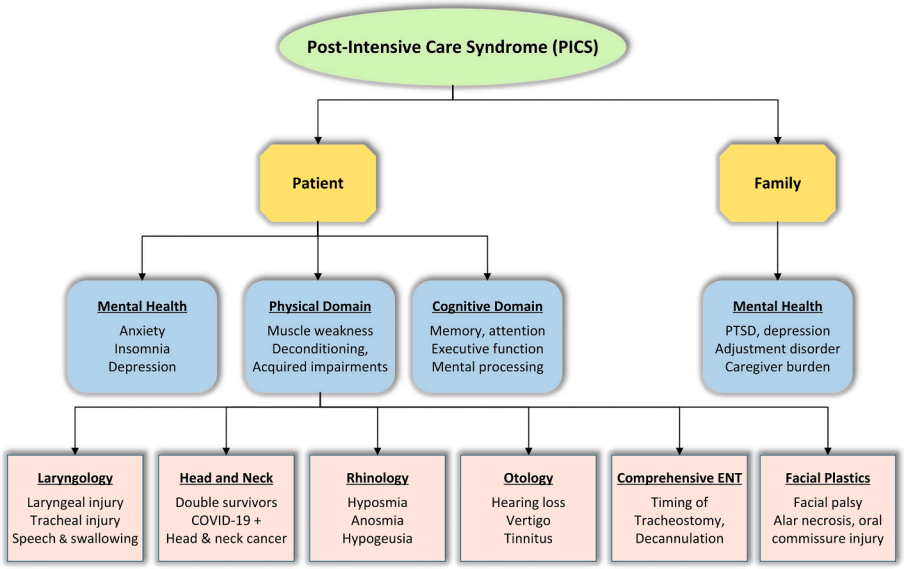

Fig. 2. Role of Otolaryngologist-Head and Neck Surgeons in COVID-19 survivorship.
Abbreviations: PTSD, post-traumatic stress disorder.

Table 1
Delineation of otolaryngology domains related to COVID-19 survivorship.

Subspecialty Area	Impairments	Management
Comprehensive Otolaryngology	Prolonged ventilator dependence	• Proactive tracheostomy timing (avoid delays) • Post-tracheostomy care, suctioning • Decannulation protocols • Multidisciplinary airway leadership
Laryngology	Laryngotracheal injury	• Laryngeal and vocal fold repair/reconstruction • Voice and swallowing rehabilitation • Surgical management of posterior glottic and subglottic/ tracheal stenosis
Rhinology, Skull Base, and Allergy	Loss of taste and olfaction	• Objective testing of taste and olfaction • Olfactory training • Topical corticosteroids sprays and rinses
Otology and Neurotology	Vertigo, hearing loss	• Audiometry • Vestibular testing • Amplification, cochlear implantation
Facial Plastic & Reconstructive	Iatrogenic pressure injuries and facial palsies	• Alar necrosis from feeding tubes • Perioral/commissure injury • Tracheostomy scar revision • Facial nerve rehabilitation
Head & Neck Oncology	New and deferred cancers, double survivorship	• Reconditioning of patients for surgery • Catch-up surveillance for cancer survivors • Managing surgical, chemoradiation and ICU-related morbidity
Cross-functional considerations	Mental health, quality of life, and preventing relapse	• Mitigate stigma and psychological sequelae • Consultation of mental health professionals • Addressing sleep, hallucinations, and PTSD • Education on vaccination, risk of recurrence • Engage family, acknowledge caregiver burden

Abbreviations: ICU, intensive care unit; PTSD, post-traumatic stress disorder.

Table 2
Otolaryngology symptoms related to COVID-19.

(Author, year)	Method	Sample Size	Tracheal injury	Pneumomediastinum	Laryngeal injury	Dysphonia	Dysphagia	SSNHL	Vertigo	Intralabyrinthine hemorrhage	Tinnitus	Headache/ encephalopathy	Gustatory disorder	Olfactory disorder	Psychosomatic
(Abou-Arab, 2020) [27]	CS	2	++	++	–	–	–	–	–	–	–	–	–	–	–
(Bassi, 2020) [28]	CS	1	+	+	–	–	–	–	–	–	–	–	–	–	–
(Bertone, 2020) [29]	CS	1	–	–	+	+	+	–	–	–	–	–	–	–	–
(Buselli, 2020) [30]	CS	1	–	–	–	+	–	–	–	–	–	–	–	–	+
(Chern, 2021) [14]	CS	1	–	–	–	–	–	+	+	+	–	–	–	–	–
(Chirakkal, 2020) [31]	CS	1	–	–	–	–	–	–	–	–	+	–	–	–	–
(Filatov, 2020) [32]	CS	1	–	–	–	–	–	–	–	–	–	+	–	–	–
(Koumpa, 2020) [33]	CS	1	–	–	–	–	–	+	–	–	+	–	–	–	–
(Lamounier, 2020) [34]	CS	1	–	–	–	–	–	+	–	–	+	–	–	–	–
(Lang, 2020) [35]	CS	1	–	–	–	–	–	+	–	–	+	–	–	–	–
(Wali, 2020) [36]	CX	5	1	5	–	–	–	–	–	–	–	–	–	–	–
(Brugliera., 2020) [37]	COH	50	–	–	–	–	90%	–	–	–	–	54%	59%	–	–
(D'Ascanio, 2020) [15]	COH	44	–	–	–	–	–	–	–	–	–	–	–	–	–
(Fiacchini, 2020) [8]	COH	30	33%	33%	–	–	–	–	–	–	–	–	–	–	–
(Hajikhani, 2020) [38]	SR	3739	–	–	–	–	–	–	–	–	–	–	49%	61%	–
(Kaye, 2020) [39]	SY	237	–	–	–	–	–	–	–	–	–	–	–	73%	–
(Lechien, 2020) [40]	EPI, MI	702	–	–	–	27%	–	–	–	–	–	–	–	–	–
(Lechien, 2020) [41]	EPI, MI	417	–	–	–	–	–	–	–	–	–	–	88%	86%	–
(Ozcelik, 2020) [42]	OBS	116	–	–	–	–	21%	5%	6%	–	11%	–	41%	38%	–

CS=case study, COH=cohort, SR = systematic review, SY=survey, EPI = epidemiologic, MI = multi-institutional, CX = case series, OBS=observational study, SSNHL = sudden sensorineural hearing loss. (Representative studies)

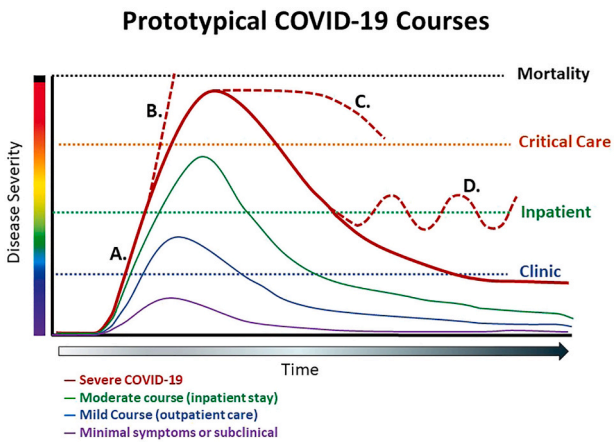

Fig. 3. Clinical courses of patients with COVID-19. A. Prototypical course of severe COVID-19, B. Progressive multiorgan failure, C. Protracted critical illness requiring extracorporeal membrane oxygenation (ECMO), D. Relapsing course requiring readmission. Other survivorship streams also depicted.

4. Voice and swallowing

Dysphonia and dysphagia are common impairments associated with weakness and deconditioning of aerodigestive muscles; acute laryngotracheal insults might exacerbate such impairments [2]. Dysphagia is much more common than dysphonia in COVID-19 patients; it may be associated with otolaryngologic symptoms—dyspnea, ear pain, facial pain, throat pain, or nasal obstruction. Aspiration pneumonia, a complication of dysphagia, is among the main reasons for hospital readmissions and mortality post-ICU, highlighting the importance of laryngeal and dysphagia evaluation (e.g., using flexible endoscopic evaluation swallowing).

5. Hearing loss and vertigo

Neurologic involvement is common in COVID-19. Although literature is limited, neurotological manifestations including ataxia, dizziness, imbalance, tinnitus, and sensorineural hearing loss have been observed [10–13]. Intralabyrinthine hemorrhage –similar to pulmonary and cerebral microhemorrhages attributed to COVID-19 associated coagulopathy– may be responsible for persistent hearing and balance disturbances [14]. Awareness of inner ear symptoms is paramount to prompt screening and timely management with oral and intratympanic steroids. Patients with persistent balance disturbances in addition to cognitive impairment are at significant risks for falls and might benefit from vestibular therapy.

6. Taste and smell

New-onset taste and smell disorders are well-recognized symptoms of COVID-19, affecting over 60% of patients [15,16]. SARS-CoV-2 entry is mediated via Angiotensin Coverting Enyzme 2 (ACE-2) and Transmembrane serine protease 2 (TMPRSS-2) receptors present throughout the olfactory cleft, with associated inflammatory disruption of the nervous system via nasal olfactory fibers [17]. Symptoms often persist for 4–6 weeks, affecting patients' overall quality of life [18–20]. While early studies demonstrate a high rate of spontaneous resolution, the residual 10% with persistent olfactory dysfunction underscore the tremendous need for improved treatment options [21]. Rhinology expertise in post-viral olfactory disorders is critical for the continued development of objective screening measures and treatments for these debilitating sequelae [22].

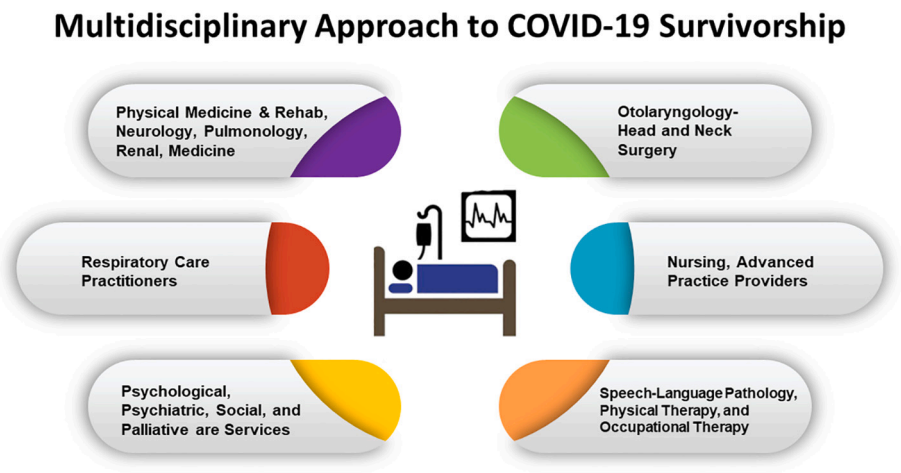

Fig. 4. Multidisciplinary engagement in care of patients with COVID-19 during and after intensive care unit stay.

7. Multidisciplinary care

In the acute phase of illness, preventative measures to minimize risk of airway injuries, such as endotracheal tube cuff pressure monitoring, airway assessment, and proactive identification of underlying causes of dysphagia or dysphonia, may reduce long-term complications (Fig. 3) [23,24]. Otolaryngologists can partner with the multidisciplinary critical care team, including speech-language pathologists, nurses, respiratory therapists, and intensivists, to guide timely diagnosis and treatment of airway injuries (Fig. 4) [25].

8. Implications for the future

Data science, machine learning, and biosensor technology will play increasingly prominent roles in patient care, ranging from early detection of physiological indicators of disease to timing for tracheostomy and other interventions to diagnosis and treatment of laryngotracheal injury or other manifestations of PICS. Prospective data registries, such as RegENT (www.entnet.org/content/reg-ent-1) and Global Tracheostomy Collaborative (www.globaltrach.org), provide platforms for data collection and analysis, risk adjustment, or future clinical prediction [1,26]. Otolaryngologists play a critical role in multidisciplinary efforts to facilitate high-quality recovery care and to improve COVID-19 patients' quality of life.

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Dr. Needham is currently, or previously, a consultant to Haisco-USA Pharmaceuticals, Novartis Pharma (Switzerland), and GlaxoSmithKline (UK), and is a principal investigator on a NIH-funded, multi-centered randomized trial (R01HL132887) evaluating nutrition and exercise in acute respiratory failure, for which Baxter Healthcare Corporation has provided an unrestricted research grant and donated amino acid product, and Reck Medical Devices has provided an equipment loan to two study sites.

CRediT authorship contribution statement

Author name	Contribution
Vinciya Pandian, PhD, MBA, MSN, ACNP-BC	Conceptualization; Data curation; Formal analysis; Methodology; Writing - original draft; review & editing.
Martin B. Brodsky, PhD, ScM, CCC-SLP	Conceptualization; Data curation; Writing - original draft, review & editing.
Emily P. Brigham, MD	Conceptualization; Data curation; Methodology; Writing - review & editing.
Ann M. Parker, MD, PhD	Conceptualization; Data curation; Writing - review & editing.
Alexander T. Hillel, MD	Data curation; Formal analysis; Methodology; Writing - original draft; review & editing.
Joshua M. Levy, MD, MPH	Data curation; Formal analysis; Methodology; Writing - original draft; review & editing.
Christopher H. Rassekh, MD, FACS	Conceptualization; Writing - original draft; review & editing.
Anil K. Lalwani, MD	Conceptualization; Writing - original draft; review & editing.
Dale M. Needham, MD, PhD, FCPA	Conceptualization; Data curation; Formal analysis; Methodology; Writing - review & editing.
Michael J. Brenner, MD, FACS	Conceptualization; Data curation; Formal analysis; Methodology; Writing – review & editing; supervision; review & editing.

Declaration of competing interest

The authors discern no conflicts of interest; however to ensure to uncomprehensive disclosure, we list the relationships above.

References

[1] McGrath BA, Brenner MJ, Warrillow SJ, Pandian V, Arora A, Cameron TS, et al. Tracheostomy in the COVID-19 era: global and multidisciplinary guidance. Lancet Respir Med 2020;8(7):717–25. https://doi.org/10.1016/S2213-2600(20)30230-7.

[2] Meister KD, Pandian V, Hillel AT, Walsh BK, Brodsky MB, Balakrishnan K, et al. Multidisciplinary safety recommendations after tracheostomy during COVID-19 pandemic: state of the art review. Otolaryngol Head Neck Surg 2020; 194599820961990. https://doi.org/10.1177/0194599820961990.

[3] Hosey MM, Needham DM. Survivorship after COVID-19 ICU stay. Nat Rev Dis Primers 2020;6(1):60. https://doi.org/10.1038/s41572-020-0201-1.

[4] Pandharipande PP, Girard TD, Jackson JC, Morandi A, Thompson JL, Pun BT, et al. Long-term cognitive impairment after critical illness. N Engl J Med 2013;369(14):1306–16. https://doi.org/10.1056/NEJMoa1301372.

[5] Bier-Laning C, Cramer JD, Roy S, Palmieri PA, Amin A, Anon JM, et al. Tracheostomy during the COVID-19 pandemic: comparison of international perioperative care protocols and practices in 26 countries. Otolaryngol Head Neck Surg 2020. https://doi.org/10.1177/0194599820961985. 194599820961985.

[6] Needham DM, Davidson J, Cohen H, Hopkins RO, Weinert C, Wunsch H, et al. Improving long-term outcomes after discharge from intensive care unit: report from a stakeholders' conference. Crit Care Med 2012;40(2):502–9. https://doi.org/10.1097/CCM.0b013e318232da75.

[7] Pandharipande PP, Girard TD, Jackson JC, Morandi A, Thompson JL, Pun BT, et al. Long-term cognitive impairment after critical illness. N Engl J Med 2013;369(14):1306–16. https://doi.org/10.1056/NEJMoa1301372.

[8] Fiacchini G, Trico D, Ribechini A, Forfori F, Brogi E, Lucchi M, et al. Evaluation of the incidence and potential mechanisms of tracheal complications in patients with COVID-19. JAMA Otolaryngol Head Neck Surg 2020. https://doi.org/10.1001/jamaoto.2020.4148.

[9] Brodsky MB, Levy MJ, Jedlanek E, Pandian V, Blackford B, Price C, et al. Laryngeal injury and upper airway symptoms after Oral endotracheal intubation with mechanical ventilation during critical care: a systematic review. Crit Care Med 2018;46(12):2010–7. https://doi.org/10.1097/CCM.0000000000003368.

[10] Mady OM, El-Ozairy HS, Wady EM. Increased incidence of otitis externa in covid-19 patients. Am J Otolaryngol 2020:102672. https://doi.org/10.1016/j.amjoto.2020.102672.

[11] Vijayasundaram S, Karthikeyan P, Mehta SD. Proficiency of virtual follow-up amongst tinnitus patients who underwent intratympanic steroid therapy amidst COVID 19 pandemic. Am J Otolaryngol 2020;41(6):102680. https://doi.org/10.1016/j.amjoto.2020.102680.

[12] Satar B. Criteria for establishing an association between Covid-19 and hearing loss. Am J Otolaryngol 2020;41(6):102658. https://doi.org/10.1016/j.amjoto.2020.102658.

[13] Sriwijitalai W, Wiwanitkit V. Hearing loss and COVID-19: a note. Am J Otolaryngol 2020;41(3):102473. https://doi.org/10.1016/j.amjoto.2020.102473.

[14] Chern A, Famuyide AO, Moonis G, Lalwani AK. Bilateral sudden Sensorineural hearing loss and Intralabyrinthine hemorrhage in a patient with COVID-19. Otol Neurotol 2021;42(1):e10–4. https://doi.org/10.1097/MAO.0000000000002860.

[15] D'Ascanio L, Pandolfini M, Cingolani C, Latini G, Gradoni P, Capalbo M, et al. Olfactory dysfunction in COVID-19 patients: prevalence and prognosis for recovering sense of smell. Otolaryngol Head Neck Surg 2020. https://doi.org/10.1177/0194599820943530. 194599820943530.

[16] Amer MA, Elsherif HS, Abdel-Hamid AS, Elzayat S. Early recovery patterns of olfactory disorders in COVID-19 patients; a clinical cohort study. Am J Otolaryngol 2020;41(6):102725. https://doi.org/10.1016/j.amjoto.2020.102725.

[17] Meng X, Deng Y, Dai Z, Meng Z. COVID-19 and anosmia: a review based on up-to-date knowledge. Am J Otolaryngol 2020;41(5):102581. https://doi.org/10.1016/j.amjoto.2020.102581.

[18] Reiter ER, Coelho DH, Kons ZA, Costanzo RM. Subjective smell and taste changes during the COVID-19 pandemic: short term recovery. Am J Otolaryngol 2020;41(6):102639. https://doi.org/10.1016/j.amjoto.2020.102639.

[19] Sakalli E, Temirbekov D, Bayri E, Alis EE, Erdurak SC, Bayraktaroglu M. Ear nose throat-related symptoms with a focus on loss of smell and/or taste in COVID-19 patients. Am J Otolaryngol 2020;41(6):102622. https://doi.org/10.1016/j.amjoto.2020.102622.

[20] Lovato A, Galletti C, Galletti B, de Filippis C. Clinical characteristics associated with persistent olfactory and taste alterations in COVID-19: a preliminary report on 121 patients. Am J Otolaryngol 2020;41(5):102548. https://doi.org/10.1016/j.amjoto.2020.102548.

[21] Fantozzi PJ, Pampena E, Di Vanna D, Pellegrino E, Corbi D, Mammucari S, et al. Xerostomia, gustatory and olfactory dysfunctions in patients with COVID-19. Am J Otolaryngol 2020;41(6):102721. https://doi.org/10.1016/j.amjoto.2020.102721.

[22] Levy JM. Treatment recommendations for persistent smell and taste dysfunction following COVID-19-the coming deluge. JAMA Otolaryngol Head Neck Surg 2020. https://doi.org/10.1001/jamaoto.2020.1378.

[23] Zaga CJ, Pandian V, Brodsky MB, Wallace S, Cameron TS, Chao C, et al. Speech-language pathology guidance for tracheostomy during the COVID-19 pandemic: an international multidisciplinary perspective. Am J Speech Lang Pathol 2020;29(3):1320–34. https://doi.org/10.1044/2020_AJSLP-20-00089.

[24] Pandian V, Morris LL, Brodsky MB, Lynch J, Walsh B, Rushton C, et al. Critical care guidance for tracheostomy care during the COVID-19 pandemic: a global, multidisciplinary approach. Am J Crit Care 2020:e1–12. https://doi.org/10.4037/ajcc2020561.

[25] Balakrishnan K, Schechtman S, Hogikyan ND, Teoh AYB, McGrath B, Brenner MJ. COVID-19 pandemic: what every otolaryngologist-head and neck surgeon needs to know for safe airway management. Otolaryngol Head Neck Surg 2020;194599820919751. https://doi.org/10.1177/0194599820919751.

[26] Brenner MJ, Pandian V, Milliren CE, Graham DA, Zaga C, Morris LL, et al. Global tracheostomy collaborative: data-driven improvements in patient safety through multidisciplinary teamwork, standardisation, education, and patient partnership. Br J Anaesth 2020;125(1):e104–18. https://doi.org/10.1016/j.bja.2020.04.054.

[27] Abou-Arab O, Huette P, Berna P, Mahjoub Y. Tracheal trauma after difficult airway management in morbidly obese patients with COVID-19. Br J Anaesth 2020;125(1):e168–70. https://doi.org/10.1016/j.bja.2020.04.004.

[28] Bassi M, Anile M, Pecoraro Y, Ruberto F, Martelli S, Piazzolla M, et al. Bedside Transcervical-Transtracheal Postintubation injury repair in a COVID-19 patient. Ann Thorac Surg 2020;110(5):e417–9. https://doi.org/10.1016/j.athoracsur.2020.04.009.

[29] Bertone F, Robiolio E, Gervasio CF. Vocal cord ulcer following endotracheal intubation for mechanical ventilation in COVID-19 pneumonia: a case report from northern Italy. Am J Case Rep 2020;21:e928126. https://doi.org/10.12659/AJCR.928126.

[30] Buselli R, Corsi M, Necciari G, Pistolesi P, Baldanzi S, Chiumiento M, et al. Sudden and persistent dysphonia within the framework of COVID-19: the case report of a nurse. Brain Behav Immun Health 2020;9:100160. https://doi.org/10.1016/j.bbih.2020.100160.

[31] Chirakkal P, Hail ANA, Zada N, Vijayakumar DS. COVID-19 and tinnitus. Ear Nose Throat J 2020;145561320974849. https://doi.org/10.1177/0145561320974849.

[32] Filatov A, Sharma P, Hindi F, Espinosa PS. Neurological complications of coronavirus disease (COVID-19): encephalopathy. Cureus 2020;12(3):e7352. https://doi.org/10.7759/cureus.7352.

[33] Koumpa FS, Forde CT, Manjaly JG. Sudden irreversible hearing loss post COVID-19. BMJ Case Rep 2020;13(11). https://doi.org/10.1136/bcr-2020-238419.

[34] Lamounier P, Franco Goncalves V, Ramos HVL, Gobbo DA, Teixeira RP, Dos Reis PC, et al. A 67-year-old woman with sudden hearing loss associated with SARS-CoV-2 infection. Am J Case Rep 2020;21:e927519. https://doi.org/10.12659/AJCR.927519.

[35] Lang B, Hintze J, Conlon B. Coronavirus disease 2019 and sudden sensorineural hearing loss. J Laryngol Otol 2020:1–3. https://doi.org/10.1017/S0022215120002145.

[36] Wali A, Rizzo V, Bille A, Routledge T, Chambers AJ. Pneumomediastinum following intubation in COVID-19 patients: a case series. Anaesthesia 2020;75(8):1076–81. https://doi.org/10.1111/anae.15113.

[37] Brugliera L, Spina A, Castellazzi P, Cimino P, Arcuri P, Negro A, et al. Nutritional management of COVID-19 patients in a rehabilitation unit. Eur J Clin Nutr 2020;74(6):860–3. https://doi.org/10.1038/s41430-020-0664-x.

[38] Hajikhani B, Calcagno T, Nasiri MJ, Jamshidi P, Dadashi M, Goudarzi M, et al. olfactory and gustatory dysfunction in covid-19 patients: a meta-analysis study. Physiol Rep 2020;8(18):e14578. https://doi.org/10.14814/phy2.14578.

[39] Kaye R, Chang CWD, Kazahaya K, Brereton J, Denneny 3rd JC. COVID-19 anosmia reporting tool: initial findings. Otolaryngol Head Neck Surg 2020;163(1):132–4. https://doi.org/10.1177/0194599820922992.

[40] Lechien JR, Chiesa-Estomba CM, De Siati DR, Horoi M, Le Bon SD, Rodriguez A, et al. Olfactory and gustatory dysfunctions as a clinical presentation of mild-to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study. European Archives of Otorhinolaryngology 2020. https://doi.org/10.1007/s00405-020-05965-1.

[41] Lechien JR, Chiesa-Estomba CM, Cabaraux P, Mat Q, Huet K, Harmegnies B, et al. Features of mild-to-moderate COVID-19 patients with dysphonia. J Voice 2020. https://doi.org/10.1016/j.jvoice.2020.05.012.

[42] Ozcelik Korkmaz M, Egilmez OK, Ozcelik MA, Guven M. Otolaryngological manifestations of hospitalised patients with confirmed COVID-19 infection. Eur Arch Otorhinolaryngol 2020. https://doi.org/10.1007/s00405-020-06396-8.