

COVID-19, New Practices in Speech Therapy

كوفيد-19، ممارسات جديدة في الأرتوفونيا

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Abstract

Speech therapy interventions targeted at COVID-19 patients, both in the acute and chronic phase, is an aspect of multidisciplinary care. It is based on speech therapy assessment leading to the formulation of diagnosis and a tailored therapeutic plan targeting dysphagia particularly post-intubation or associated with neuromyopathy acquired in intensive care; organic dysphonia mainly including laryngeal immobility, or functional dysphonia associated with coordination impairment in the organs responsible for voice production; taste and smell disorders resulting from the neurological sequelae of the viral infection; and the linguistic-cognitive disorders associated not only with neurological damages, but also with mental disorders.

This article aims to identify the various effects that COVID-19 may have on the main areas of speech therapy, and, accordingly, identify the appropriate rehabilitation methods.

Keywords: COVID-19; dysphagia; dysphonia ؛ anosmia-ageusia; language disorders.

ملخص :

يُعدُّ التدخل الأرتوفوني لفائدة مرضى كوفيد-19، سواء في المرحلة الحادة أو المزمنة، وجها من أوجه التكفل متعدد التخصصات الذي يعتمدُ على تقييم أرتوفوني شامل، يُفضي إلى تشخيص دقيق ووضع خطة علاجية موافقة. يستهدف هذا التدخل أساسا الديدسفاجيا، خصوصا بعد التنبيب أو الناجمة عن مرض عصبي عضلي للإنعاش؛ الاضطرابات الصوتية، على غرار البحة العضوية الناجمة عن إصابات حركية الثنايا الصوتية أو عن خلل وظيفي مرتبط بسوء التنسيق بين الأعضاء المسؤولة عن إنتاج الصوت؛ كما يشمل هذا التدخل اضطرابات الذوق والشم الناتجة عن

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التأثيرات العصبية للعدوى الفيروسية؛ إلى جانب الاضطرابات اللغوية والمعرفية التي قد تعود إلى تلف عصبي، أو اضطرابات عقلية مصاحبة.

يهدف هذا المقال إلى تحديد الآثار المحتملة التي قد تنجم عن الإصابة بكوفيد-19 على المجالات الرئيسية في الأرتوفونيا وكذا طرق إعادة التأهيل وفقا لذلك.

الكلمات المفتاحية: كوفيد-19؛ ديسفاجيا؛ بحة صوتية؛ أنوسميا- أقوزيا؛ اضطرابات اللغة.

Introduction

A number of respiratory-infection cases were reported in early December 2019 in Southeast China. The agent that caused these infection cases was soon identified as a novel betacoronavirus of bat origin, and named later SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus). This virus causes COVID-19 (Coronavirus Disease) that is defined by the World Health Organization (WHO) as a respiratory illness that may be fatal (De Andrade et al., 2020).

Patients with COVID-19 may experience a number of symptoms; the most common of these are respiratory complications. These complications necessitate intubation that consists in the insertion of a tube into the trachea to offer assisted mechanical ventilation. However, as a result of this intervention, two main impairments may be cause: dysphonia and dysphasia. While the former is mainly a consequence of a trauma affecting the vocal cords and the laryngeal mobility, the latter affects swallowing abilities leading to higher risks of aspiration. In the two cases, the intervention of the speech therapist is highly significant. In addition to offering guidance on correct posture and appropriate food texture, the speech therapist works on orofacial-musculature stimulation and strengthening.

Other widely reported COVID-19-related symptoms include a loss of taste (scientifically referred to as *ageusia*) and a loss of smell (scientifically referred to as *anosmia*). In such cases, the speech therapist focuses on restoring sensory functions by using certain sensory-stimulation techniques.

In addition to the above, cognitive impairments are also observed in certain patients with COVID-19. These have been reported to significantly affect the patients' capacity for effective communication.

In this regard, the World Health Organization (WHO) has acknowledged the importance of speech therapists' role in managing COVID-19 patients,

particularly symptomatic patients or those who have undergone intubation. Following the post-extubation phase, these patients often experience complications in breathing and swallowing. Therefore, speech therapists play a vital role within the multidisciplinary team, contributing to the assessment, rehabilitation, and, when necessary, the implementation of appropriate therapies (Martins *et al.*, 2022).

There are various COVID-19 related complications that may require speech therapists' intervention. This paper focuses on dysphagia, dysphonia, smell and taste disorders, Language and Cognitive Disorders.

The central objective of this study is to examine the range of rehabilitation interventions in speech therapy aimed at individuals experiencing the above-mentioned symptoms.

1. Dysphagia

Since the outbreak of COVID-19 pandemic in 2019, swallowing disorders have been reported to be difficult to manage. When SARS-CoV-2 infects cells via the ACE-2 receptor (angiotensin-converting enzyme), it actually affects multiple organs, especially the lungs. As a result, patients may experience respiratory difficulties. Also, it has been noted that COVID-19 and its treatments may cause swallowing impairment, respiratory issues, neurological effects, and muscle weakness. The study carried out by Eyigör and Umay (2020) offers a comprehensive review of the current scientific literature and available data on COVID-19 impact on swallowing and its management. In the same vein, among the COVID-19 patient population of the study carried out by Özçelik Korkmaz *et al.* (2020) about 20.6% were noted to experience dysphagia.

There are certain patient-specific factors that may increase the risk of severe COVID-19-related dysphagia. Older adults face significantly higher mortality rates, partly due to age-related muscle loss, weak respiratory function, and reduced sensory and immune responses, all of which may affect swallowing (scientifically referred to as presbyphagia). Also, comorbidities such as cardiovascular disease, diabetes, Chronic Obstructive Pulmonary Disease (COPD), and hypertension, may further raise fatality and dysphagia risks by impairing swallowing and coordination. Smoking may also be considered a factor; this damages lung function, suppresses protective reflexes, and harms

respiratory and pharyngeal tissues. These factors may trigger or worsen dysphagia in COVID-19 patients (*Eyigör and Umay, 2020*).

Furthermore, beside the lungs, COVID-19 may affect multiple systems and may lead to conditions that contribute to dysphagia risk increase. Loss of taste and smell in COVID-19 patients may contribute to long-term swallowing and nutritional problems. Also, neurological impairments, including delirium and cranial nerve dysfunction, may further affect swallowing. In addition, malnutrition and muscle wasting, due to inflammation, sedation, or poor intake, also contribute significantly to dysphagia (*Eyigör and Umay, 2020*).

The above emphasizes the need for careful swallowing and nutritional assessment in COVID-19 patients. (*Ibid*)

COVID-19 treatments, particularly in severe cases, may significantly increase the risk of dysphagia. Applying high-flow nasal oxygen therapy for improving oxygenation may impair the swallowing reflex and the breathing-swallowing coordination. Patients in intensive care, subjected to endotracheal intubation or tracheostomy, are at especially high risk due to direct trauma, sensory loss, and muscle atrophy. Also, prolonged intubation, sedation, and prone positioning further contribute to dysphagia and aspiration risk. Sedatives and opioids may also impair swallowing and increase gastroesophageal reflux. Therefore, clinicians must be aware of these risks, especially in patients with severe COVID-19, to ensure early identification and management of dysphagia (*Eyigör and Umay, 2020*).

COVID-19 patients subjected to intubation are likely to develop dysphagia. However, a study by Grilli *et al.* (2022), in which 41 non-intubated patients participated, revealed that even patients without invasive ventilation experienced varying degrees of swallowing difficulties. The authors used a Swallowing Disturbance Questionnaire (SDQ) and a Volume-Viscosity Swallow Test (VVST) to identify dysphagia symptoms in non-intubated COVID-19 patients. Younger patients were particularly affected, suggesting that age was not a key factor. Also, pre-existing respiratory conditions such as asthma and COPD showed a significant correlation with dysphagia due to impaired breathing-swallowing coordination.

According to the same study, on the other hand, normal swallowing processes may be disrupted due to COVID-19-triggered anosmia and ageusia conditions after viral damage to cranial nerves and sensory pathways. These effects, along with reduced oropharyngeal sensitivity and neuromuscular dysfunction, may result in impaired bolus control, and increased risk of aspiration.

In light of the above, it may be noted that although the study used a small sample, and lacked assessment of pneumonia severity, it highlighted the importance of recognizing dysphagia in non-intubated COVID-19 patients and the need for further research into its mechanisms and management.

2.1. Rehabilitation of dysphagia

Eyigör and Umay (2020), summarized the recommendations of the international dysphagia communities in order to reduce infection risk. These communities recommend that rehabilitation protocols during the COVID-19 pandemic should be adapted by varying treatment duration, frequency, and setting. To achieve rehabilitation goals, compensatory rehabilitation methods with shortened sessions are preferred. Low-risk exercises involving the tongue, lips, neck, temporomandibular joint, and Shaker exercises are encouraged. High-risk interventions (such as thermal tactile stimulation and respiratory muscle training, face-to-face breathing exercises and coughing maneuvers) are not recommended. Oral hygiene practices are vital, with povidone-iodine or hydrogen peroxide preferred over chlorhexidine. Strict adherence to infection control measures, including personal protective equipment (PPE) protocols, ventilation, physical distancing, and limiting session time, is essential. Electrical and transcranial magnetic stimulation treatments are generally deferred, except where supported by specific guidelines. Non-oral nutrition is advised when swallowing safety is compromised, favoring percutaneous endoscopic gastrostomy over nasogastric tubes due to lower risk. Telemedicine is widely endorsed for dysphagia diagnosis and follow-up, especially in neurological patients, provided the patient meets cognitive and physical criteria and has caregiver support (*Eyigör and Umay, 2020*).

1.2. Dysphagia and Bilateral Vocal Fold immobility

Associated with Bilateral Vocal Fold Immobility, dysphagia is the predominant complication when the vocal folds are fixed in an abducted

position. The severity of the disorder depends heavily on three factors: the degree of glottic closure, the prospects for functional recovery, and the etiology of the condition. In cases of severe dysphagia, oral feeding may be inappropriate; instead, the implementation of enteral-feeding strategies may be necessary.

Quick therapeutic intervention is necessary to face the life-threatening risks posed by silent aspiration. If the disorder is transient, spontaneous resolution is possible, and compensatory strategies are easy to introduce. Behavioral interventions, such as targeted swallowing techniques and postural adjustments, are typically recommended during the period awaiting neuromuscular recovery.

Targeted therapeutic management may bring about benefits over short or extended time, depending on the extent of recovery and the evolving dynamics of laryngeal function. This management includes exercises targeting both intrinsic and extrinsic laryngeal musculature, retraction exercises for the posterior base of the tongue, and functional rehabilitation techniques such as the super-supraglottic swallow maneuver, which facilitates both glottic and supraglottic closure (*Gatterie, 2003*).

When surgical intervention involving vocal fold adduction is required, speech therapy also plays an important role during the postoperative rehabilitation phase (*Gatterie, 2003*).

2. Dysphonia

With reference to Covid-19, Amberger (2021) argues that vocal alterations may occur as a result of four main causes: (1) lesions or inflammation affecting the nerves, blood vessels, or lungs; (2) sequelae associated with prolonged intubation; (3) voice disorders linked to continuous mask usage; and (4) disorders of psychosomatic origin.

The study of Tekiela and Majersik (2021) notes that approximately 13.5% of patients develop neurological complications within two days from symptom onset.

The vagal neuropathy has been frequently associated with viral infections. This may result in vocal fold paralysis due to involvement of the recurrent laryngeal nerve, leading to a weak, breathy, and high-pitched voice, or impair

pitch modulation when the superior laryngeal nerve is affected. Also, patients may develop Paradoxical Vocal Fold Motion, characterized by inappropriate closure of the glottis during inspiration or following phonation; this often manifests as dyspnea and a limited ability to sustain speech. Hypothyroidism may also be triggered as a result of thyroid vascularization caused by damaged vagal nerve. Hypothyroidism may contribute to a reduction in the tone and elasticity of the larynx, soft palate, tongue, and vocal folds, culminating in a hypofunctional dysphonia characterized by a nasal, weak voice (Amberger, 2021).

From a vascular perspective, the direct interaction between SARS-CoV-2 and angiotensin-converting enzyme 2 (ACE2) receptors, cause endothelial cell dysfunction and may contribute to the development of dysphonia by weakening the muscles and causing edema of the vocal folds (Vance *et al.*, 2020 ; Castillo-Allendes *et al.*, 2020)

The common results include prolonged shortness of breath (four to six weeks), and chronic cough, which may inflict mechanical trauma on the vocal folds and mucosa and may cause hemorrhage. Pulmonary function tests may reveal a flattened inspiratory flow-volume loop, suggestive of vagal nerve neuropathy. To compensate for respiratory difficulties, many patients adopt an upper thoracic and oral breathing pattern, which can induce excessive laryngeal tension and adversely affect vocal quality (Amberger, 2021).

Amberger (2021) notes that, in cases of prolonged intubation (an average duration of 21.8 days), a significant proportion of patients exhibit post-intubation voice disorders. Laryngoscopic examination reveals that 93.8% present with glottic abnormalities, including impaired vocal fold vibration (87.5%), incomplete closure (50%), asymmetry (50%), unilateral paralysis or paresis (40%), posterior glottic gap (15%), and stenosis (10%). Notably, 45% of these patients require surgical intervention (Naunheim *et al.*, 2020). Additionally, granuloma formation may occur in patients experiencing excessive vocal use or gastroesophageal reflux following extubation (Castillo-Allendes *et al.*, 2020)

Heider and colleagues (2020), associates the use of face masks for longer periods of time with vocal strain. He noted that approximately 33% of individuals required to wear a mask throughout the workday reported voice complaints often with observed headaches, dermatological issues, and breathing difficulties. He also noted that masked speakers increased their vocal intensity

by 10 to 15 Db in order to achieve intelligibility levels comparable to unmasked speakers; this led to chronic vocal effort and potential phonotrauma.

On the other hand, the study revealed that a large number of patients were diagnosed with psychosomatic dysphonia or aphonia although no laryngeal lesions were detected. Instead, high emotional stress, social isolation, and the psychosocial consequences of the pandemic were associated with the condition. The author listed the following symptoms: air hunger, sternal tightness, a globus sensation, oral breathing, and chronic fatigue. Also, laryngoscopic findings often revealed increased muscular tension without structural pathology. The author also noted that such psychogenic voice disorders have become increasingly prevalent since June 2020, and are observed among both Covid-positive and Covid-negative individuals (*Amberger, 2021*).

Ishii et al. (2021) note that dysphonia has been a common complaint during the COVID-19 pandemic and especially among patients who have undergone tracheotomy. The authors categorize dysphonia into two main types: organic and functional.

Among the organic causes, the most frequently observed are the lesions of the posterior glottis (granulomas), and laryngeal paralysis. The authors suggest that speech therapy may be considered for initial management of isolated hemilaryngeal paralysis, however, in case of insufficiency, or if swallowing disorders are also present, they suggest to consider temporary endoscopic vocal fold medialization using a resorbable material (*Ishii et al., 2021*).

Ishii *et al.* (2021) argue that hyperfunctional dysphonia is the most common functional form, and associate it with poor breath control and compensatory vocal and postural tension. They also suggest that post-COVID-19 respiratory sequelae may impair breathing-phonation coordination, leading to vocal misuse. On the other hand, they argue that chronic pain and the physical impact of intensive care may alter posture and worsen the condition. Therefore, they suggest involving phoniatric and speech therapy follow-up in the management in order to release compensatory tensions and restore more efficient vocal technique.

Campos *et al.* (2022) raised the possibility that dysphonia may be a result of long-COVID or COVID-related chronic fatigue and cognitive impairment. In

the same vein, the results of a study of individuals experiencing long COVID with associated “brain fog”, carried out by Jennings and colleagues (2022), showed that found that those patients experienced higher frequencies of voice weakness and throat pain than those without “brain fog” cognitive impairment. Stavrides *et al.* (2017) acknowledged that the adverse effects of chronic fatigue on the voice are well known.

2.1. Rehabilitation of dysphonia

Ishii *et al.* (2021) suggest that patients with tracheostomy should receive daily speech therapy; this includes laryngeal reafferentation exercises, and a gradual resumption of swallowing and phonation. Amberger (2020) emphasizes that the rehabilitation of voice, breathing, and swallowing disorders after COVID-19 yields good results and is similar to that of patients with the same symptoms without having contracted the disease.

2.2. Dysphonia and Bilateral vocal fold Immobility

Puech (2003) noted that, in abducted position, dysphonia is consistently observed in cases of bilateral vocal fold immobility and may be significantly severe when the glottic aperture is maximally widened. It is recommended in preoperative speech therapy to focus on strengthening both the intrinsic and extrinsic laryngeal musculature. The aim is to support neural recovery, maintain muscular tone and functionality, and prevent maladaptive laryngeal compensatory behaviours.

The author also noted that, after medialization surgery, a temporary tracheostomy is commonly required. It is typically after the closing of the tracheostomy stoma that voice rehabilitation begins.

The author emphasized that, following surgical procedure involving glottis opening, it is necessary for the patient to spend a period of vocal rest. During this period, therapy is applied in order to enhance tissue healing and minimize complications risks. A targeted voice rehabilitation program should be started when the local anatomical and functional conditions are conducive to therapy (Puech, 2003).

3. Disorders of taste

Disorders of taste may either refer to a partial or a total inability to recognize the five fundamental tastes; these are sweet, salty, bitter, sour, and umami. However, there are various degrees of taste recognition as follows:

- The complete absence of taste recognition is referred to as **ageusia**.
- A reduction in taste sensitivity is termed **hypogeusia**.
- A distorted or altered taste recognition is described as **dysgeusia or parageusia**.

Albert (2021) mentioned a variety of causes that trigger taste disorders. He added that they are, most frequently, associated with dry mouth (scientifically referred to as *xerostomia*); this is specifically a result a hyposialia, an impairment that affects salivary gland function.

In addition other causes. These include systemic conditions such as Sjögren's syndrome and localized pathologies such as oral candidiasis. The author also emphasized that medications highly contribute to dysgeusia. He noted that 200 medications (including antibiotics, antidiabetic agents, and antihypertensive drugs) have been identified as potential contributors to taste alterations, primarily through their effects on salivary function.

In the same context, oncology patients may also experience taste disturbances. According to Albert (2021) taste disturbances are commonly observed among oncology patients. The study results revealed that more than half of the patients undergoing chemotherapy and over 90% of those receiving radiotherapy to the oral or pharyngeal region reported experiencing taste change. Various factors lead to taste dysfunction; these include:

- Oral microbiome dysbiosis, often associated with inadequate oral hygiene, gastroesophageal reflux disease, the presence of extensive tumors in the throat tongue, or prolonged antibiotic therapy;
- Oral mucositis, an inflammatory condition affecting the mucous membranes resulting from chemotherapy or radiotherapy toxicity, viral or fungal infections, or active tobacco consumption;

- Damaged taste buds by direct cytotoxicity, resulting from chemotherapeutic agents, such as platinum salts and anthracyclines. In this context, it has been noted that, in some cases, this damage may persist even after the treatment;
- Salivary gland dysfunction leading to xerostomia, especially during radiotherapy involving the oral cavity or oropharynx;
- Diminished olfactory function;
- Surgical procedures involving the tongue for the treatment of ENT cancers, which may result in ageusia through the destruction of taste receptors.

Less frequent causes of taste disorders may include traumatic brain injuries or neoplastic lesions. In addition, it should be noted that aging process naturally reduces taste sensitivity. This physiological decline, akin to that observed in other sensory modalities, may lead to a diminished appetite in older individuals due to reduced gustatory pleasure. This phenomenon is known as presbygeusia (Albert, 2021).

4. Olfactory Disorders

Olfactory disorders, also referred to as dysosmias, are in most cases acquired, but may also be present from birth. These olfactory disorders may be categorized as follows:

❖ **Quantitative disturbances: these include:**

- _ *Anosmia* occurs when odors are no longer perceived at all.
- _ *Hyposmia* occurs when odor perception is diminished.
- _ *Hyperosmia* occurs when odors are perceived too intensely.

❖ **Qualitative disturbances: these include:**

- _ *Parosmias*, which are distortions in perceived smells, an odor that was once pleasant becomes unpleasant.
- _ *Cacosmias*, which are perceptions of foul odours not detected by others.
- _ *Phantosmias* (or *phantom smells*), which are olfactory hallucinations.

Albert (2021) also observed fluctuations in olfactory disorders; these include a selective loss of sensitivity to certain odour categories. For example, he noted that, during the recovery phase, pleasant smells tend to be perceived more readily than unpleasant ones. This phenomenon remains poorly understood, though.

Loss of smell may be a result of:

- A peripheral impairment due to nasal cavity obstruction, leading to inability to detect odours, or from changes in the olfactory mucus;
- An intermediate impairment affecting the olfactory nerve, causing failure to transmit olfactory information;
- A central impairment affecting the manner in which olfactory information is processed in the brain;
- Or from a combination of all the mentioned causes.

Obstruction of the nasal cavities may occur in several conditions, such as:

- *Rhinitis*, an inflammation of the nasal mucosa, which may have various origins, including allergies (e.g., allergic rhinitis);
- *Sinusitis*, an inflammation of the mucous membranes lining the sinuses;
- *Naso-sinus polyps*, referring to the development of polyps in the mucosal lining;
- *Nasal septum deviation*;
- *Empty nose syndrome*, a rarer cause, resulting from complete resection of the inferior and/or middle turbinates.

The olfactory nerve may be affected, among others, by:

- Exposures to toxic substances, particularly drugs inhaled through the nose;
- Certain infections, especially those caused by the influenza virus, the herpes virus, and more recently, by SARS-CoV-2;
- Traumatic brain injuries;
- Tumours.

Ankri (2009) noted that, at the cerebral level, degeneration of neurons located in the olfactory bulb may impair the ability to recognize taste or smell. The author asserts that it is now widely accepted within the scientific community that progressive loss of smell and taste recognition is an early indicator of

neurodegenerative diseases such as Alzheimer's or Parkinson's disease. Populations at risk should be aware of this.

It is also known that psychological trauma may lead to severe olfactory disturbances, even though the physiological mechanisms underlying these impairments are not yet fully understood. However, they are nonetheless real and visible through imaging (Albert, 2021).

4.1. Post-Covid Anosmia

Since the outbreak of the pandemic, the prevalence of taste and smell loss in patients infected with Covid-19 led infectious disease specialists and ENT physicians to consider these symptoms as defining indicators of the disease, even before testing became widely available (Lechien et al., 2020 ; Boudjema et al., 2020). Patients with the mentioned symptoms are generally young, in good health, and typically do not develop severe forms of the illness requiring hospitalization.

The nasal cavities are an established entry point for SARS-CoV-2. This latter, then, binds to ACE-2 receptors (angiotensin-converting enzyme) located in the olfactory mucosa.

According to Albert (2021), anosmia may be triggered by several factors, each implying different prognoses:

- The coronavirus may cause a peripheral impairment, affecting the nasal cavities or the olfactory clefts. It may induce localized inflammation, thereby preventing odour molecules from binding to receptors in the olfactory mucosa. In such cases, once the inflammation subsides, the sense of smell typically recovers spontaneously, usually within three weeks;
- The virus may also bind to the fibers of the olfactory epithelium that project toward the olfactory bulbs. The resulting inflammatory response leads to partial destruction of the olfactory neurons through desquamation of the olfactory epithelium, which loses part of its superficial layer. This mechanism is likely a defensive strategy by the body to prevent the virus from reaching the cerebral compartment. The recovery prognosis in such cases is significantly longer, as the olfactory neurons need time to regenerate, a process that can take several months up to two years (Michel, 2021). Olfactory stimulation encourages this

neuronal regrowth, which must be supported by specific rehabilitation to ensure proper recovery conditions.

– There may also be a central involvement, particularly at the level of the olfactory bulbs, along with hypometabolism in certain brain regions, that is, reduced activity in areas of the brain that are connected to the olfactory system (*Dias de Melo et al., 2021 ; Guedj et al., 2021*). The origin of this hypometabolism is still unknown: viral damage? inflammatory injury? partial destruction of cerebral tissue? (*Albert, 2021*).

4.2. Long Covid Syndrome

Following infection with COVID-19, a study noted that approximately 10% of patients continue to experience fluctuating symptoms for several months. The study also noted that this persistence of the symptoms often affects individuals who initially had only a mild form of the disease. Within the scientific community, the precise pathophysiological mechanisms for this prolonged symptom persistence are still not well understood.

Long-COVID cases generally tend to present recurrent patterns of symptom clusters. These symptoms may fall into distinct categories; while some are predominantly respiratory or cardiovascular, others are primarily neurocognitive in nature. Persistent fatigue, dyspnea, depressive symptoms, heart palpitations, insomnia, joint and muscular pain, and neuropsychological impairments, including difficulties in memory, attention, and executive functioning, as well as disturbances in olfactory and gustatory perception, may all be present to varying extents.

Initially, many healthcare professionals regarded these post-viral syndromes as predominantly subjective in nature. However, subsequent investigations, most notably those led by Prof. Guedj at APHM, demonstrated that patients experiencing such signs, from three weeks to several months after the infection, exhibit cerebral hypometabolism; this is defined as reduced metabolic activity in specific brain regions.

In patients with long COVID, this decline in cerebral function primarily affects the olfactory bulbs to varying degrees.

Additionally, hypometabolism is observed in multiple brain regions anatomically and functionally connected to these initial sensory relay centers.

These include the limbic system (notably the hippocampus and amygdala), which governs memory and emotional processing; the brainstem, which is essential for autonomic control of respiration, sleep, and cardiac rhythm; and the cerebellum, responsible for coordination, motor control, and balance (*Guedj et al., 2021*).

Younger individuals appear to be disproportionately affected, often displaying more pronounced patterns of hypometabolism in cases where post-COVID syndromes persist over extended periods.

Nevertheless, a notable discrepancy remains between the hypometabolism detected through PET imaging and the absence of identifiable structural lesions. The study posits that these findings most likely represent functional disturbances within all the interconnected regions of the olfactory network. These disruptions may result from a form of “congestion” that impedes the fluid relay of sensory information.

According to the recommendations issued by the *Haute Autorité de Santé* “HAS” (the English equivalent for this should be: Higher Health Authority), patients who continue to experience post-COVID symptoms beyond four weeks after initial infection should seek assessment by their physician. The primary care provider may initiate additional diagnostic workups, prescribe symptomatic treatments, and, where necessary, refer the patient for rehabilitation.

Olfactory rehabilitation, by directly stimulating the olfactory bulb and the brain’s initial sensory entry point, may play a contributory role in resolving these dysfunctions. This form of therapy may initiate a self-reinforcing (virtuous) cycle of sensory recovery, particularly when combined with appropriate pharmacological or supportive medical treatments (*Guedj et al., 2021*).

4.3. Olfactory Rehabilitation

In his study, Lechien (2021), noted that approximately 60% of patients infected with COVID-19 reported a loss of smell and taste. However, the majority recovered within a period of two to three weeks. By the beginning of sixth month, an estimation of 90% of patients, initially presenting with anosmia, have regained olfactory function, primarily due to rehabilitation. For the remaining 10%, recovery is typically slower and more complex, though not unattainable.

Olfactory rehabilitation through the application of strong odour stimuli has been practiced for several years and is a well-established method among otolaryngologists. Recently, additional therapeutic exercises have been proposed to target not only peripheral olfactory structures but also the cerebral functions integral to olfactory processing. The aim is twofold: to promote the regeneration of olfactory receptor neurons and to enhance the brain's capacity for cognitive interpretation of sensory input.

- Rehabilitation exercises include:

- Preparatory exercise: stress management
- Repeated exposure training to various odors
- Mental olfactory imagery
- Simulated olfaction linked to memory
- Emotional analysis
- Enhancing olfactory capacity (*Albert, 2021*).

4.4. Relearning how to taste

Stimulating the sense of smell through the orthonasal route (via the nose) aids in the recovery of taste. In addition, it is necessary to work on the perception of aromas in the mouth through the retronasal route, which connects the nasal cavities to the palate.

Next, gustatory stimulation is encouraged by playing with flavors, textures, and engaging the other senses, while seeking to restore the pleasure of tasting (*Albert, 2021*).

- *Retronasal olfaction* is the technique used by speech therapists to help patients who have undergone tracheotomy regain the ability to smell. This involves the “polite yawning” method (*Bensafi and Rouby, 2020*).
- Enhancing taste through *umami*.
- A multi-sensory menu.
- Flavor pairings.
- The importance of visual presentation (*Albert, 2021*).

5. Language and Cognitive Disorders

Among the symptoms of long Covid, neuropsychological sequelae are frequently observed following infection by SARS-CoV-2, regardless of the severity of respiratory involvement during the acute phase. These deficits appear to stem not only from neurological damage but also from the development of psychiatric disorders (*Benzakour et al., 2021*).

Data remains limited, especially regarding which specific cognitive domains are affected, as well as the influence of psychiatric symptoms, known to have a significant impact on cognitive function (*Benzakour et al., 2021*).

Among patients who experience SARS-CoV-2-related pneumonia in the acute phase, 38.6% exhibit neurological symptoms, sometimes even before the onset of respiratory symptoms (*Mao et al., 2020*). This has been corroborated by numerous studies reporting that such neurological manifestations may be accompanied by neuropsychological impairments, including confusion, severe dysexecutive syndrome, attention fluctuations, and language disorders (*Helms et al., 2020*).

Additionally, an increased prevalence of strokes has been reported in Covid-19 patients, leading to further neurological and cognitive deficits in both the short and long term. The nature and severity of these impairments depend on the location and extent of the brain lesion (*Oxley et al., 2020*).

To date, and to the best of our knowledge, few studies have explored the long-term consequences of SARS-CoV-2 infection on cognition (*Almeria et al., 2020*; *Wu et al., 2020*). One such study relied on a validated and standardized neuropsychological methodology, conducted between 10 and 40 days after hospitalization for Covid-19. The authors reported impairments in short-term memory (STM), attention, and executive functions (such as inhibition, cognitive flexibility, or working memory) (*Almeria et al., 2020*).

In another study conducted between 20 and 105 days following the onset of mild to moderate respiratory symptoms during the acute phase of infection, the authors employed a brief early cognitive screening tool via telephone, the Modified Telephone Interview for Cognitive Status (M-TICS), and similarly concluded that significant differences existed between the patient group and the control group (*Woo et al., 2020*).

These cognitive deficits were most pronounced in the areas of attention, language, and memory. Notably, the observed impairments did not correlate with symptoms of depression, fatigue, or somatisation (Woo *et al.*, 2020).

However, these findings must be interpreted with caution due to multiple methodological limitations and inherent biases. The studies in question did not account for patients' neurological, psychiatric, or developmental histories; they failed to assess instrumental domains such as visuospatial abilities, gestural functions, or visuoconstructive praxis; and they lacked standardized evaluations of emotional or affective symptoms (Benzakour *et al.*, 2021).

5.1. Management of Neuropsychological Disorders

Persistent cognitive impairments following SARS-CoV-2 infection must be systematically screened, regardless of whether patients spontaneously report cognitive complaints. Specialist consultations, neurological and psychiatric, should be pursued whenever feasible, alongside a comprehensive general clinical evaluation (Benzakour *et al.*, 2021).

Depending on the outcome of these specialized consultations, a formal neuropsychological assessment may assist in confirming the presence of cognitive dysfunction and delineating specific impairment profiles that may help identify the underlying etiology. Similarly, neuroimaging may be warranted based on clinical presentation and diagnostic indications (Benzakour *et al.*, 2021).

The therapeutic strategy should remain cautious and grounded in pragmatism, particularly given the current paucity of evidence regarding the optimal management of emerging post-COVID neuropsychological symptoms (Benzakour *et al.*, 2021).

Regular re-assessments of treatment efficacy must be planned, allowing for potential therapeutic adjustments in collaboration with the patient. Treatment should be both symptomatic and etiological whenever feasible. Sessions in neurorehabilitation and neuropsychoeducation may be indicated depending on the nature of the cognitive disturbances and their functional repercussions. For example, neurorehabilitation has demonstrated encouraging results in improving memory, attention, and executive function (Wilson *et al.*, 2009). In instances where a psychiatric etiology is established, appropriate psychotherapeutic and pharmacological interventions must be proposed (Benzakour *et al.*, 2021).

Conclusion

SARS-CoV-2 is responsible not only for problems at the respiratory system level, but also for a broad spectrum of additional impairments: neurological, neurocognitive, cardio-vascular, digestive, hepatorenal, metabolic, psychiatric, among others.

Based on the studies presented in this paper, it was possible to infer that the COVID-19 pandemic has an important impact on the most diverse areas of speech therapy (dysphagia, dysphonia, anosmia-ageusia, speech and language disorders, and cognitive impairment). As a result, certain individuals will require prompt assessment followed by targeted and sustained speech therapy interventions within a multidisciplinary team.

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