Objective: Swallowing disorders are systematically present in patients with severe brain injury, disorders of consciousness, and subsequently poor quality of life. The study hypothesis was that taste and smell could improve swallowing function and quality of life in such patients, who are fed by gastrostomy tube.

Methods: Eight patients with unresponsive wakefulness syndrome were included in this study. All patients had been in a stable state for at least 2 years, and the delay between the neurological event and the study was always more than 2 years. Strong tastes and smells were selected using the Pfister olfactory classification. Taste and smell stimulations were performed every weekday, Monday to Friday, for 1 week (5 sessions) by a speech and language therapist. Evaluation of swallowing was performed before the first session and after the fifth session, and included the number of spontaneous swallows during 10 min, the presence of drooling, and spontaneous tongue and velum mobility.

Results: The number of spontaneous swallows at the initial evaluation was 6.8 ± 5.1 n/min. At the final evaluation there was a significant increase in the number of spontaneous swallows (9.1 ± 4.1 n/min, p < 0.01).

Conclusion: This clinical observation has shown that taste and smell stimulations are relevant in clinical practice to improve spontaneous swallowing.

Key words: consciousness disorders; traumatic brain injury; dysphagia; deglutition disorders; taste; smell.

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Correspondence address: Eric Verin, Rouen Normandy University Hospital, 1 rue de Germont, 76031 Rouen cedex. E-mail: eric.verin@univ-rouen.fr

Swallowing disorders and oropharyngeal dysphagia are systematically present in patients who have severe brain injury and disorders of consciousness (DoC), who mostly require exclusive feeding by gastrostomy (1). Clinical observations indicate that swallowing and hypersalivation might be induced by taste and smell. Indeed, taste and smell have many links with central neuronal structures, such as the amygdala, the hippocampus, the insula and the orbital frontal cortex, which are also involved in the organization of swallowing (Fig. 1) (2). Olfactory signals reach the olfactory receptor neurones either directly, via the orthonasal route, or, for the majority of signals, indirectly, via the retronasal route from the oral cavity behind the soft palate. After stimulation of the neurones of the olfactory epithelium, the information is transmitted via an axon that crosses the cribriform plate of the ethmoid bone and synapses at the level of the olfactory bulbs, to the cortical olfactory areas (septal area, uncus and amygdala body) and the hypothalamus (3).
Taste comprises 4 basic gustatory modalities: sweet, sour, salty and bitter. Its transduction is initiated in the taste buds of the oropharynx, larynx and upper third of the oesophagus. The taste buds are innervated by the facial, glossopharyngeal and vagus cranial nerves (4). Peripheral gustatory fibres enter the brainstem and the nucleus tractus solitarius (NTS) before projecting to higher centres. It has been shown that interneurones in the NTS can be either excited or inhibited by taste stimuli (5). Oral sensory input, including taste, plays a critical role in the normal

Fig. 1. Neuroanatomy of taste, smell and swallowing showing the different networks involved in: (a) Neuroanatomy of taste in sagittal plane of the brain, (b) Neuroanatomy of smell in median plane of the brain and (c) Neuroanatomy of swallowing in sagittal plane and projections in the oral cavity of swallowing. LN: lingual nerve (mandibular nerve Vc; trigeminal nerve (V)); CT: chorda tympani; VII: facial nerve; LB (IX): lingual branches (glossopharyngeal nerve (IX)); X: vagus nerve; NST: nuclei of solitary tract (VII, IX, X); ML: medial lemniscus; VPLN: ventral posterolateral nucleus (thalamus); PTA: primitive taste area (post-central gyrus); ON: olfactory nerves; OB: olfactory bulb; OT: olfactory tract; SN: septal nuclei; U: uncus (parahippocampal gyrus; limbic lobe); AB: amygdaloid body; H: hippocampus; PMA: primitive motor area (pre-central gyrus); IC: internal capsule; CNF: corticonuclear fibres (pyramidal tract); NA: nucleus ambiguus (myelencephalon); XI: glossopharyngeal nerve; pharyngeal and stylopharyngeal branches; X: vagus nerve; pharyngeal branch; pharyngeal plexus; SLN: superior laryngeal nerve; RLN: recurrent laryngeal nerve (right: subclavian artery; left: aorta); NXII: nucleus of hypoglossal nerve (myelencephalon); XII: hypoglossal nerve.
modulation of volitional swallowing (6). Therefore, by activating sensory receptors, taste and other sensory stimuli are likely to provide significant inputs to the NTS and higher centres by regulating swallowing activity. In our experience, patients with unresponsive wakefulness syndrome (UWS) (7) may have spontaneous saliva swallowing. Based on current knowledge of the network of taste and smell and their links with swallowing function, it was therefore hypothesized that taste and smell might induce swallowing in patients with UWS, thus contributing to the process of improvement in swallowing.

Data are presented as means and standard deviation (SD). The number of spontaneous swallows, tongue mobility and velum mobility were compared before the first evaluation and after the last evaluation using a Student’s t-test. Differences were considered statistically significant if \( p < 0.05 \).

**METHODS**

To examine this hypothesis, this study evaluated taste and smell stimulation in 8 patients with UWS (Table I). All patients had been in a stable state for at least 2 years. The patients’ families gave consent for the patients to participate in this non-invasive and observational study, which was approved by the local ethics committee (Rouen university hospital (E 2021-71)).

Assessment of level of consciousness was performed using the Coma Recovery Scale revised (CRS-R) (8) and the Wessex Head Injury Matrix (WHIM) (9) at the beginning of the protocol. Strong tastes and smells were selected using the Pfister olfactory classification. Four different tastes were used: fruity (orange, banana), empyreumatic (chocolate, coffee), vegetal (tea, garlic) and spicy (vanilla, mint). To stimulate the sense of smell, these different substances were crushed and placed 5 cm in front of the patient’s nose for 10 min. To stimulate the sense of taste, orange juice, crushed banana, chocolate yogurt, vanilla yogurt, espresso coffee, tea, and mint syrup were used. The different substances were placed on a large cotton swab, which was positioned on the patient’s tongue for 10 min. The swab had a long tail, which was held by the operator. The taste and smell stimulations were performed every weekday, Monday to Friday, for 1 week (5 sessions) by a speech and language therapist, with a washout position before the test.

To examine this hypothesis, this study evaluated taste and smell and their links with swallowing function, thus contributing to the process of improvement in swallowing.

**RESULTS**

Patients’ characteristics are shown in Table I. All 8 patients had a prolonged DoC, and none of them had an oral diet. All underwent the different tests without any sign of refusal or discomfort. The tests were performed in 6 patients in a sitting position in a wheelchair and in 2 patients in a supine position in bed. Three patients received initial labial stimulation to open their mouth, and no patient rejected the swab placed in their mouth. Head positioning was enabled by the adapted wheelchair. The number of spontaneous swallows at the first evaluation was 6.8 ± 5.1 swallows per minute. Four patients had drooling suggestive of severe oropharyngeal dysphagia. At the final evaluation, there was a significant increase in the number of spontaneous swallows (9.1 ± 4.1 swallows per minute, \( p < 0.01 \)). There was no change in tongue mobility or velum mobility. Dripping was either not clinically modified, or increased slightly, during the test.

**DISCUSSION**

This simple clinical observational study shows that taste and smell stimulations, performed once a day during 5 consecutive days in patients with UWS increased the number of spontaneous swallows. Two questions should be discussed: first, the mechanism involved in the increased number of swallows after taste and smell stimulations, and secondly, the role of sensory stimulation in the rehabilitation of patients with UWS in arousal units.

Regarding the effects of taste and smell, it is possible that the heightened sensory input may have been enhanced in our patients who had received no sensory stimulation for at least 2 years. Perhaps all the tasting substances induced a heightened awareness of an unusual flavour in the mouth or nose. Indeed, attention and other emotive dimensions associated with swallowing function have been implicated in functional imaging studies, which have demonstrated activation of, for example, the anterior cingulate cortex during the task of swallowing. Neurological control of swallowing is achieved through the action of cranial nerves, brain stem control centres and the cortex. The mostly mixed pairs of cranial nerves convey the information of the afferent and efferent pathways. Brainstem control of swallowing involves cortical afferents and efferents, allowing the voluntary control of swallowing, which could argue for cortical activity in the study patients. At the cortical level, unlike other somatic functions, the swallowing muscle is bilateral, and asymmetrical with a minor and major hemisphere. The descending pathways are the

**Table I.** Characteristics of the 8 included patients

| Characteristics of the population | mean SD               |
|----------------------------------|-----------------------|
| Age (y)                          | 49.6 ± 12.9           |
| Sex (female)                     | 2                     |
| Duration since injury, in years  | 8.3 ± 6.4             |
| WHIM (max 62)                    | 7 ± 6                 |
| CRS-R (max 23)                   | 5 ± 3                 |

SD: standard deviation; WHIM: Wessex Head Injury Matrix; CRS-R: Coma Recovery Scale revised.
Swallowing activation in severe disorders of consciousness

Swallowing activation in severe disorders of consciousness –
ration, may be performed as part of sensory stimulation
taste stimulation, adapted to minimize the risk of aspi
therefore often not exposed to taste stimulation. Whilst
nutrition is given via gastrostomy tube and the patient is
lowing in these patients with DoC, in clinical practice all
patients with extremely poor quality of life.

In conclusion, this simple clinical observational study
highlights the possibility of oral activity and swallowing
response in patients with UWS. Further studies into swal-
lowing evaluation and rehabilitation in patients with
UWS are needed.

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