Predictive factors of severity and persistence of oropharyngeal dysphagia in sub-acute stroke

Alessandro De Stefano, Francesco Dispenza, Gautham Kulamarva, Giuseppina Lamarca, Antonio Faita, Antonio Merico, Giuseppe Sardanelli, et

European Archives of Oto-Rhino-Laryngology
and Head & Neck

ISSN 0937-4477
Volume 278
Number 3

Eur Arch Otorhinolaryngol (2021)
278:741-748
DOI 10.1007/s00405-020-06429-2

Springer

European Archives of Oto-Rhino-Laryngology (2021) 278:741–748
https://doi.org/10.1007/s00405-020-06429-2

LARYNGOLOGY

Predictive factors of severity and persistence of oropharyngeal dysphagia in sub-acute stroke

Alessandro De Stefano[1] · Francesco Dispenza[2] · Gautham Kulamarva[3] · Giuseppina Lamarca[1] · Antonio Faita[4] · Antonio Merico[4] · Giuseppe Sardanelli[4] · Salvatore Gabellone[4] · Antonio Antonaci[5]

Received: 15 May 2020 / Accepted: 7 October 2020 / Published online: 17 October 2020

Abstract

Purpose This study aims to understand the factors contributing to the severity of oropharyngeal dysphagia and its persistence in the sub-acute phase of stroke.

Methods We retrospectively collected the data of all the patients suffering from a stroke in the last year. The severity of stroke was reported according to the NIHSS score. All the patients were evaluated with the Dysphagia Risk Score and with a FEES. We classified the Dysphagia Risk Score and FEES results using the PAS score and ASHA-NOMS levels. The data were analysed statistically with ANOVA test, Student's *t* test and Pearson's correlation coefficient.

Results A series of 54 patients were evaluated. The ANOVA test did not find any difference in the mean score of Dysphagia Risk Score, PAS and ASHA-NOMS when compared with the brain area of stroke. An NIHSS at hospital admission (stroke unit) of more than 12 was predictive of ASHA-NOMS score 1–4 after 60 days ($p < 0.05$). A PAS score between 6 and 8 at first FEES evaluation was predictive of poor (1–4) ASHA-NOMS score after 60 days ($p < 0.01$). A moderate positive linear correlation was found between NIHSS score and both PAS (r 0.65) and Dysphagia Risk Score (r 0.50); a moderate negative linear correlation was recorded between NIHSS and ASHA-NOMS (r −0.66) scores.

Conclusion In the sub-acute phase of stroke, the predictive factors of persistent dysphagia are not linked to the damaged neuroanatomical region and others factors such as NIHSS value and high PAS score seem more useful.

Keywords Dysphagia · FEES · Stroke · Aspiration · Nasogastric tube · Predictor factors

Introduction

Stroke or cerebrovascular accidents, as we all know, is a result of a disturbance in the vascular supply of the brain, causing loss or impairment of the respective functions of the region of the brain affected [1]. It may be ischemic or hemorrhagic depending on whether there is an occlusion of the vasculature or its rupture [1]. There can be two phases of stroke. The acute phase which last for about 2 weeks after the onset of lesion and the sub-acute phase last up from 2 weeks to 6 months after onset [2]

Cerebrovascular accidents are the second leading cause of preventable death worldwide and the fourth leading cause of lost productivity, as measured by disability-adjusted life years. According to estimates by the World Health Organization, stroke accounted for 5.7 million deaths and 16 million first-time events in 2005 and these numbers may reach 7.8 million and 23 million by 2030, respectively [2].

Oropharyngeal dysphagia (OD) affects more than 50% of the patients suffering from a stroke. Fortunately, the majority of them recover swallowing function within a few weeks (during the sub-acute phase of stroke) and only 11–13% remain dysphagic after 6 months or more [3].

Unfortunately, OD occurring as a major sequelae of stroke is also the principal cause of death in these patients,

✉ Alessandro De Stefano
dr.adestefano@gmail.com

1 U.O. Foniatria, Dipartimento di Riabilitazione, ASL Lecce, Piazza Bottazzi, 73100 Lecce, Italy

2 U.O. Otorinolaringoiatria, Policlinico Giaccone, Università degli Studi di Palermo, Palermo, Italia

3 ENT Department, Maithri Speciality Clinics, Mangaluru, India

4 U.O. Medicina Fisica e Riabilitazione Neuromotoria, Ospedale "Santa Caterina Novella", ASL Lecce, Galatina (Lecce), Italia

5 Dipartimento di Riabilitazione, ASL Lecce, Lecce, Italia

mainly due to aspiration pneumonia and/or malnutrition [4] For these reasons, OD screening becomes necessary to avoid the possibility of aspiration (overt or silent) leading to complications such as aspiration pneumonia, dehydration, malnutrition, or airway obstruction [5].

Screening of OD is usually performed by a trained Speech–Language–Pathologist (SLP) along with a clinical evaluation of patient's features before and/or after water intake. Currently, a variety of methods are used in which the vigilance status, the presence of dysarthria, the presence of dysphonia, the motility of the tongue and mouth, the presence of pharyngeal reflex, the presence of cough reflex and voluntary cough, and changes in the vocal quality after water swallowing are considered. These evaluation techniques are considered the mainstay of dysphagia management and as the first line of assessment, it defines the process and requisites of the task [6].

Instrumental evaluation of swallowing function is often requested for this class of patients to be sure of the safety of recommencing swallowing. It also helps in assessing whether the nasogastric tube can be safely removed, whether new food consistencies can be safely introduced in the oral diet after the SLP rehabilitation training or to decide to perform a Percutaneous Endoscopic Gastrostomy (PEG) in patients who have failed the SLP management.

Today, it is possible to evaluate the oropharyngeal dysphagia by Videofluoroscopic swallowing study and fiberoptic endoscopic evaluation of swallowing (FEES) [7, 8]. Though these exams are considered equivalent to each other, Kelly et al. in 2006 showed that pharyngeal residue and aspiration are better identified by FEES rather than videofluoroscopy [8].

Despite our ability to detect and manage OD using instrumental methods, clinical screening and SLP rehabilitation, deciding about the appropriate time to remove the nasogastric tube is still difficult to predict. This is because the swallowing function is controlled by a complicated brain network involving both hemispheres and the brainstem [9]

Various brain regions have been shown to participate in the control of swallowing. The most cited brain areas that have been identified—mainly through lesion studies—include the primary sensorimotor cortex, sensorimotor integration areas, the insula and frontal operculum, the anterior cingulate cortex, parietooccipital region, basal ganglia, thalamus, cerebellum, and supplementary motor areas [10–12].

Specifically, insula region appears to play an important role in swallowing due to the evidence that a lesion in the insular cortex produces profound dysphagia [1]. Mosier et al. suggested that insula belonging to both the sides participates during swallowing.[13]. Another study observed the activation of the right insula during swallowing [14, 15] while Lowell et al. showed that the interactions of the left insula with other brain areas were more prominent than the right one during volitional swallowing [16].

This study is an attempt to understand which factors contribute to the severity of dysphagia and its persistence in the sub-acute phase of the stroke.

Patients and methods

We collected retrospective data of all the patients suffering from stroke and were managed for suspected OD at our tertiary referral centre for swallowing disorders (U.O. Foniatria—Dipartimento di Riabilitazione-ASL Lecce, Italy) in the last year (from 01 January 2019 to 31 December 2019). All the patients recruited for the study belonged to the sub-acute intensive rehabilitation unit after being discharged from the stroke unit.

All the patients with a diagnosis of acute, unilateral cortical, subcortical or subtentorial stroke according to the World Health Organization [17] along with the presence of OD defined by abnormal swallowing physiology of the upper aerodigestive tract or as detected from clinician testing including screening, clinical bedside, or FEES were included in this study.

The patients with previous history of swallowing difficulty, past stroke, progressive neurological disorder, severe deficits in language comprehension, history of surgery in the head and neck regions, radiotherapy or chemotherapy for cancer in the head and neck regions, and past history of vocal fold paralysis were excluded from the study.

All patients were diagnosed to be suffering from acute unilateral stroke by expert neurologists supported by radiological evaluations (MRI or CT). We then recorded the demographic, clinical data and stroke location systematically.

Hospitalisation duration for all the patients was calculated from the date of admission into the stroke unit (acute stroke phase) to discharge from the hospital. The time spent in the stroke unit was between 10 and 12 days followed by transfer to a sub-acute intensive rehabilitation unit (sub-acute stroke phase).

The circulation territory of all the stroke patients was divided into anterior and posterior, as previously defined by Tatu [18].

We reported the severity of stroke upon admission into the stroke unit as per the National Institute of Health Stroke Scale (NIHSS) score [19]. It was then classified into a minor stroke, moderate stroke, moderate to severe stroke, and severe stroke.

In the sub-acute intensive rehabilitation unit, all patients suspected to be suffering from OD underwent evaluation by a trained SLP with the Dysphagia Risk Score (DRS) by Amitrano [20]. An Otolaryngologist experienced in the evaluation of dysphagia graded the severity of dysphagia with the help of FEES. We adopted a personally modified standardised FEES protocol. Specifically, during the FEES examination, the participants were offered three trials of thin and three trials of thick liquid followed by one small bite-sized banana (soft solid) and cracker (hard solids). Each thin liquid trial contained 10 ccs of water and each thick liquid contained 10 ccs of aquagel (Nestlè Nutricia Nutilis®) and was dyed with blue food colouring. All patients received the same consistences during the FEES evaluation making the population tested homogenous. The hard and soft solid consistencies were tested only if there were no signs of dysphagia with thin and/or thick liquids.

Our FEES results were classified using the Penetration Aspiration Scale (PAS) and divided into three groups: normal (PAS1), penetration (PAS Scores 2–5) and aspiration group (PAS Scores 6–8) [21].

At the end of each ENT examination and speech pathologists evaluation, the OD was classified using the American Speech–Language–Hearing Association (ASHA) National Outcome Measurement System (NOMS) swallowing levels [22].

To asses the improvement of OD after stroke management, our patients were stratified into three groups: Tube feeding (from ASHA-NOMS 1 to 3), moderate OD (from ASHA-NOMS 4 to 5) and minimal OD/normal (from ASHA-NOMS 6 to 7).

Data of first FEES score, first PAS score and first ASHA-NOMS score were described as T0.

Every day, patients received SLP rehabilitation therapy. The patients also underwent new FEES examination every 15–20 days until the day of discharge from the hospital ward. The new test results were indicated with a progressive numerical value of T.

Changes of PAS score and ASHA-NOMS levels were recorded after the final evaluation for the whole series. A change in the grouping score, rather than the mere value was considered as an improvement.

Initial FEES results along with ASHA-NOMS classification guided the SLPs in the rehabilitation of the OD. The protocol for rehabilitation included compensatory strategies to maintain safety, nutrition and hydration. They achieved this by changing the consistency of food and by modifying swallow with head tilt, head turn and chin tuck. Exercises and/or manoeuvres such as Masako, Shaker, Mendhelshon, supraglottic swallow, super-supraglottic swallow and Effortful swallow [23] also helped in improving and enhancing the swallowing mechanisms.

Statistical analysis

The sample data recorded were reported as mean, median and standard deviation for quantitative variables; percentage for qualitative variables. All data were analysed with MS Excel® 2019.

Student's t test was performed for quantitative variables and Chi-squared test for qualitative variables; a p value < 0.05 was considered statistically significant.

The analysis of variance or ANOVA test assessed the differences in DRS, PAS score and ASHA-NOMS levels between the groups.

Pearson's correlation coefficient (r) estimated the linear correlation between quantitative variables.

This study followed all the ethical guidelines and rules of our ward.

Results

A series of 54 patients were retrospectively evaluated following admission to our hospital for stroke. Thirty of our patients were males and 24 were females. The mean age was 75.1 years (± 12.4) with a median of 79.5.

Twenty-five patients had a stroke involving their right side of the brain and the remaining 29 suffered from a stroke of the left brain. When we analysed the brain site involved, 26 cases had cortical involvement, 16 cases had subcortical involvement, both cortical-subcortical involvement was seen in 9 patients, and subtentorial in the remaining 3 cases. In 46 patients, the stroke was involving the anterior sector of cerebral circulation, and in 8 cases, it was involving the posterior sector. In our series, the average NIHSS we observed was 11.9 (± 9.08). Upon assessing the severity, it was observed that 13 cases had a minor stroke, 29 were moderate, 4 moderate to severe, and 8 patients suffered from a severe stroke.

Our cohort of patients had an average DRS of 5.68 (± 4.5) with a median value of six. Twenty-four of our patients with high DRS received nasogastric tube feeding. After the FEES performed at T0, the mean PAS stood at 3.8 (± 2.06) with a median value of 3. The mean ASHA-NOMS score after the first clinical evaluation was 3.7 (± 1.63) with a median score of four. On an average, the patients were hospitalised for 44.79 (± 18.45) days. Follow-up evaluation T1 done between 15 and 20th days after the first evaluation T0 gave us the following results: mean PAS 3.09 (± 1.9) median 2.5, and mean ASHA-NOMS 4.57 (± 1.6) median of five. After a further 45 days (T2), the scores were: mean PAS 2.52 (± 1.83) with a median of two, and mean ASHA-NOMS 5.03 (± 1.59) with a median score of five.

The ANOVA test did not find any difference in the mean score of DRS, PAS and ASHA-NOMS in correlation with the area of the brain affected by the stroke (cortical, subcortical or subtentorial).

Ischemic and haemorrhagic stroke did not show a statistically significant difference in DRS, PAS and ASHA-NOMS score ($p > 0.05$) after admission to the sub-acute intensive rehabilitation unit.

A positive linear correlation, as displayed in Fig. 1, was found between NIHSS score and both PAS (r 0.65) and DRS (r 0.50). Likewise, a negative linear correlation was recorded between NIHSS and ASHA (r −0.66) score.

Only one patient amongst our patient group had a worsening of the dysphagia during hospitalisation. It was due to a deterioration in the level of consciousness.

The PAS remained the same as at the time of admission in the sub-acute intensive rehabilitation unit in 17 cases (31.4%), and the ASHA-NOMS score too was unchanged in 14 cases (25.9%). Twenty-three (42.5%) patients improved the PAS results after 60 days of hospitalisation from the onset of stroke and 28 (51.8%) patients improved to a better score for ASHA-NOMS at discharge from sub-acute intensive rehabilitation unit.

An NIHSS value at hospital admission (stroke unit) of more than 12 was predictive of a modification in ASHA-NOMS score to 1–4 after 60 days ($p < 0.05$) (Fig. 2) indicating severe or moderate dysphagia. However, the NIHSS was not indicative of improvement in PAS and/or ASHA-NOMS score during the hospitalisation ($p > 0.05$).

Categorising the patients by age did not show any correlation with improvement in PAS and ASHA-NOMS score during hospitalisation ($p > 0.05$) (Fig. 3).

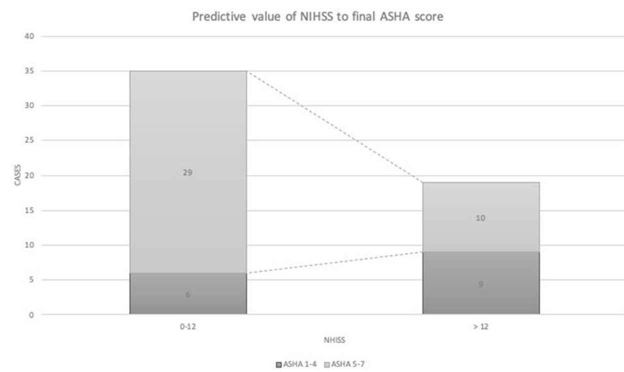


Fig. 2 Predictive value of NIHSS more than 12 to have a poor ASHA score after 60 days since hospitalization. *ASHA* American Speech Hearing Association, *NIHSS* National Institute of Health Stroke Scale

A PAS between 6 and 8 at T0 was predictive of poor (1–4) ASHA-NOMS score after 60 days ($p < 0.01$).

Hemorrhagic stroke reflected a poor ASHA-NOMS score after 60 days ($p < 0.05$), but this stroke type did not modify the PAS score.

The necessity of nasogastric tube feeding during at hospital admission (Stroke Unit) and its persistent need even after admission into the sub-acute intensive rehabilitation unit predicted a poor score in both PAS and ASHA-NOMS after 60 days ($p < 0.01$).

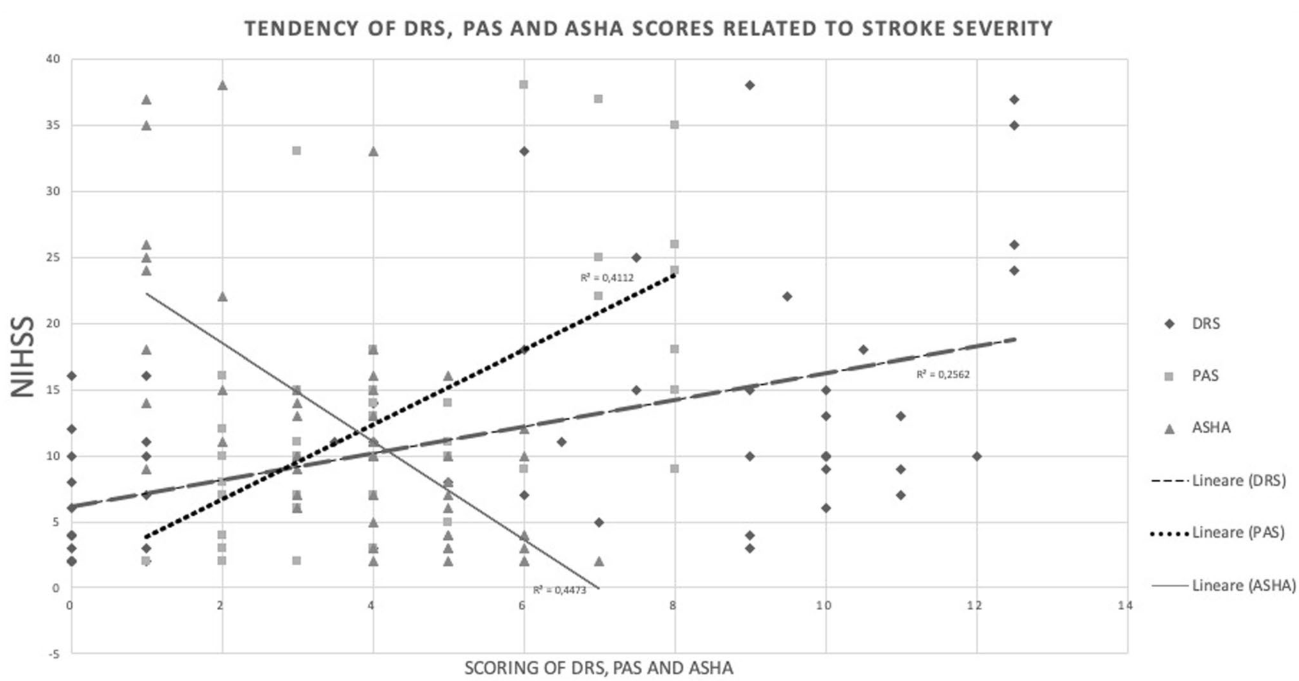
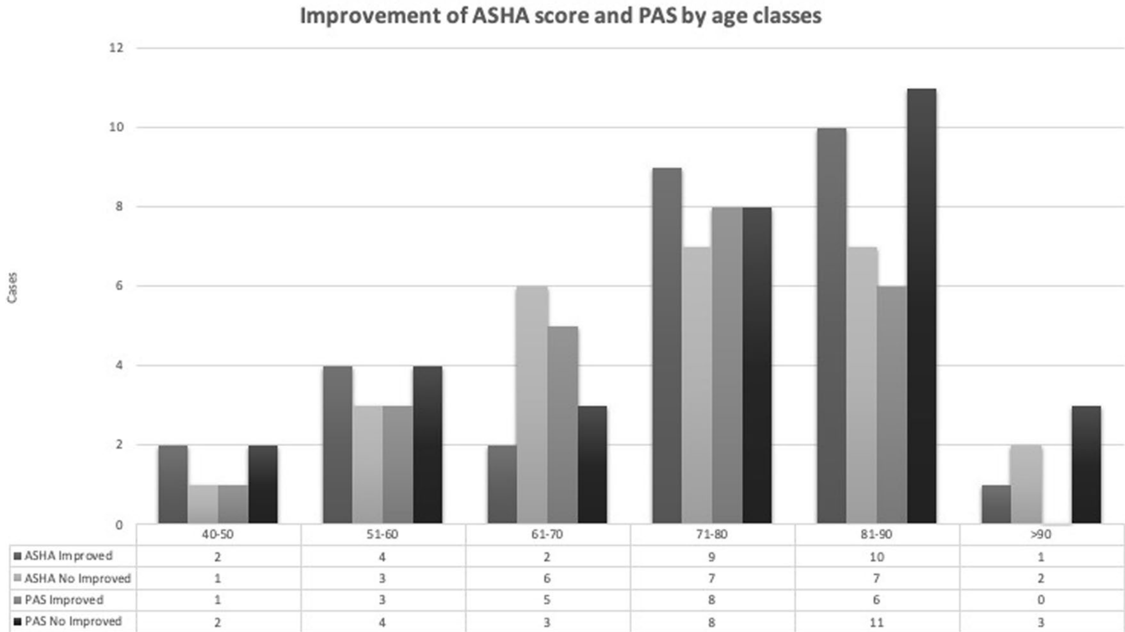


Fig. 1 The scatter plot shows distribution of dysphagia scores in relationship with severity of stroke. Although the distribution is not immediately clear, the tendency lines (and *R* value) of the DRS, PAS and ASHA scores demonstrate that exists a positive correlation between PAS and DRS score with NHISS severity, and a negative correlation with ASHA score, although the *R* value is notstatistically significant. *DRS* Dysphagia Risk Score, *PAS* Penetration Aspiration Score, *ASHA* American Speech Hearing Association, *NIHSS* National Institute of Health Stroke Scale

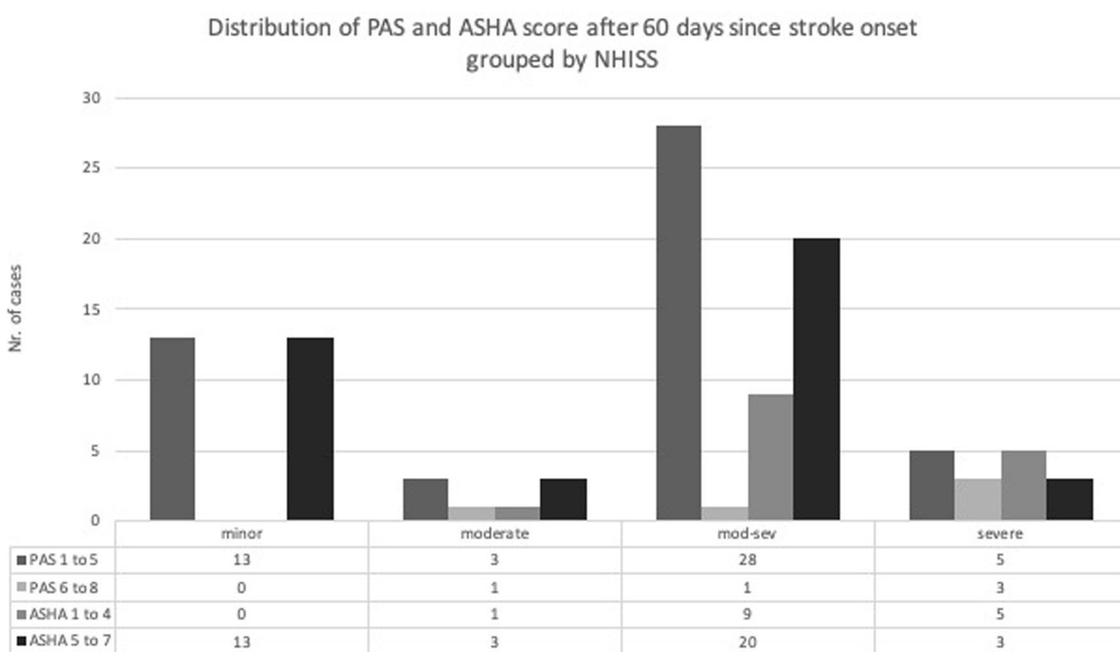


	40-50	51-60	61-70	71-80	81-90	>90
ASHA Improved	2	4	2	9	10	1
ASHA No Improved	1	3	6	7	7	2
PAS Improved	1	3	5	8	6	0
PAS No Improved	2	4	3	8	11	3

Fig. 3 Number of patients with modification of ASHA score and PAS during hospitalization, distributed by age classes. *PAS* Penetration Aspiration Score, *ASHA* American Speech Hearing Association

Prolonged hospitalisation beyond 60 days too was related to worse ASHA-NOMS score ($p < 0.01$) (Fig. 4), on the contrary, it was not predictive of poor PAS at discharge.

There was no correlation between the area of brain involved by stroke and the severity of dysphagia at discharge. ($p > 0.05$).



	minor	moderate	mod-sev	severe
PAS 1 to 5	13	3	28	5
PAS 6 to 8	0	1	1	3
ASHA 1 to 4	0	1	9	5
ASHA 5 to 7	13	3	20	3

Fig. 4 Distribution of PAS and ASHA score after 60 days since hospitalization according to NIHSS class of severity. *PAS* Penetration Aspiration Score, *ASHA* American Speech Hearing Association, *NIHSS* National Institute of Health Stroke Scale

Discussion and conclusion

Oropharyngeal dysphagia is very common in stroke and also is one of the most important causes of morbidity in these patients.

Despite all the advances in current evaluation techniques and understanding of OD in patients suffering from stroke, many a time it is still difficult to decide to reestablish oral feeds and the safety of doing it. Our present study aims to investigate the factors that may be influencing the severity of dysphagia as well as its persistence during the sub-acute phase of the stroke.

In a recent study, Suntrup et al. described that distinct location patterns of brain lesions correlated well with the incidence, severity and patterns of swallowing dysfunction [24]. Specifically, the authors wrote that the involvement of primary and secondary sensory-motor cortex is strongly associated with dysphagia [24]. On the other hand, a reorganisation of the pharyngeal motor cortex appears rapidly in the unaffected hemisphere after stroke. This is the key to swallowing recovery in these patients with dysphagia following stroke [25].

To our surprise, in our patient population, the ANOVA test did not show any difference in the mean scores of DRS, PAS or ASHA-NOMS with the area of brain injury. If we try to understand this finding, in our study design, only those patients who had a unilateral stroke with dysphagia were included. Therefore, all our patients had an unaffected hemisphere of the brain available to compensate for and help in recovery from dysphagia. This can explain the uniform severity of dysphagia across all the sites of injury.

Apart from this, the first assessment of our patients we did, both clinically as well as endoscopically was after transfer to the sub-acute stroke unit. By the time we could assess, it is very likely that the mechanisms of re-organisation of the motor pharyngeal cortex in the unaffected side had already begun as hypothesised by Hamdy in 1997 [26] and recently confirmed by Cohen in a 2016 study [25].

Hamdy in an other study published in the year 2000 postulated that within the brain there is an interhemispheric asymmetry in the cortical representation of swallowing and OD appears only when the largest (most dominant) projection is damaged [27]. This postulate clarifies that there may be anatomically similar strokes in which OD does not appear or appears while recovery of the swallowing function starts, increases in the first 2 weeks after the acute event, and finally, the recovery depends on the healing capacity of the healthy hemisphere of the brain [25, 27].

Even ischemic and hemorrhagic strokes did not show a statistically significant difference in DRS, PAS and ASHA-NOMS scores ($p > 0.05$) at T0. But the presence of a hemorrhagic stroke upon admission to Stroke Unit correlated to a poor ASHA-NOMS score after 60 days.

Today we know that in case of ischemic stroke, patterns of dysphagia may differ from that of haemorrhagic stroke. In haemorrhagic stroke, we observe an effect on other regions of the brain due to the intracranial mass effect from the extravasation of blood [28] and this feature was radiologically evident on our CT scans (Fig. 5). This is the most likely reason behind our findings of poorer outcome in this subset as reflected in our results.

The NIHSS value at hospital admission (stroke unit) of more than 12 was predictive of ASHA-NOMS score 1–4 after 60 days. This result was in line with the 2014 and 2015 studies of Kumar and Toscano in which the severity of stroke was an important predictor of persistent OD with a suggested NIHSS cutoff value of ≥ 12 [29, 30].

In our study, we have also had other connected predictive factors of persistent OD 60 days following a stroke. They were: the presence of a nasogastric tube and a PAS score between 6 and 8 after the first 10–12 days since admission in hospital (T0). Besides this, prolonged hospitalisation of the patient too contributed to a persistent OD indicated by poor levels of the ASHA-NOMS classification at discharge.

The presence of aspiration detected during FEES (PAS score 6–8) in patients suffering an acute stroke was described in the recent literature as a predictive factor of persistent OD [29]. In fact, if the swallow does not show any signs of recovery in the first 10 days after stroke, the return of a safe swallow may take up to two or more months.[25]. For this reason, in our sub-acute stroke patients, the presence of an aspiration

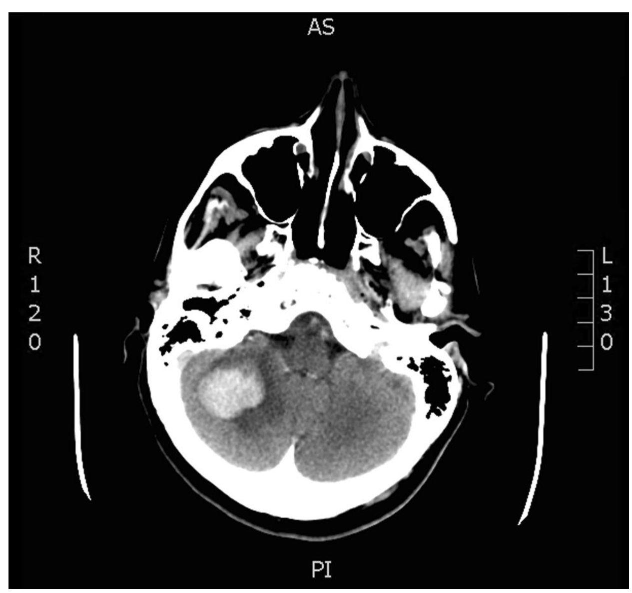


Fig. 5 Axial CT scan of right cerebellar hemorrhagic stroke with surrounding edema causing effect mass on neighbouring structures

grade PAS score at T0 and the need for the nasogastric tube were indicative of persistence of OD. In our opinion, it is probably due to a poor brain reorganisation of the swallowing function following the damage.

The last predictive factor of poor recovery of swallowing was prolonged hospitalisation. We know that a period of physical inactivity during hospitalisation compromises functional capacities [31, 32]. In a non-dysphagic patient, it is well described that after 10 days of bed rest, aerobic capacity and lower extremity muscle strength are reduced [33]. Patients affected by severe dysphagia may also experience a similar phenomenon during swallowing, with disuse of pharyngeal muscles and suprahyoid muscles contributing to the increase in the difficulty of swallowing [34]. Apart from this, prolonged hospitalisation would mean either a more severe variety of stroke to start with or a poorer ability of the patient to recover. Either or both of these would mean the global recovery chances of the patient is suboptimal and likewise the chances of recovery of OD too.

These aspects of impaired efficacy of swallowing are not directly caused by a stroke but they form a part of the natural history of stroke and they can also remain in the chronic stroke phase reducing the swallowing function in 50% of the patients [35, 36].

In conclusion, we observed in our patients affected by unilateral sub-acute stroke that the damaged neuroanatomical region and the patient's age were less important than other factors in predicting the prognosis of dysphagia. The presence of stroke initially classified with an NIHSS value of more than 12 and a PAS score indicative for aspiration (from 6 to 8) in a sub-acute period along with the presence of nasogastric tube predicted the persistence of dysphagia better. These two factors if present 2 weeks after the acute event should be indicative for a poor re-organisation of the pharyngeal motor cortex in the unaffected hemisphere.

The other predictive factors for persistent OD in sub-acute phase are the presence of a mass effect linked to cerebral haemorrhage (in cases of hemorrhagic strokes) and prolonged hospitalisation that can aggravate the swallowing scenario already compromised by stroke.

Knowledge of the predictive factors of OD in sub-acute phase of stroke appears very important for the right management of these patients during the hospitalisation.

Specifically, the Otolaryngologist will image the evolution of OD and he will counsel, in according to SLP, to rehabilitate these patients with clear and targeted goals over time avoiding having unattainable expectations.

References

1. Otto DM, Ribeiro MC, Barea LM, Mancopes R, Almeida ST (2016) Association between neurological injury and the severity of oropharyngeal dysphagia after stroke. Codas 28(6):724–729
2. Kuklina EV, Tong X, George MG, Bansil P (2012) Epidemiology and prevention of stroke: a worldwide perspective. Expert Rev Neurother 12(2):199–208
3. Smithard DG, O'Neill PA, England RE et al (1997) The natural history of dysphagia following a stroke. Dysphagia 12(4):188–193
4. Benvenuti CM, Pereira LM, Revay MA. Disfagia pos-acidente vascular cerebral isquemico unilaterale m adultos: estudo de caso (thesis). Florianopolis (SC). Centro de EspecializaǴao em Fonoaudiologia clinica; 2005: 29p.
5. González-Fernández M, Ottenstein L, Atanelov L, Christian AB (2013) Dysphagia after stroke: an overview. Curr Phys Med Rehabil Rep 1(3):187–196
6. Carnaby-Mann G, Lenius K (2008) The bedside examination in dysphagia. Phys Med Rehabil Clin N Am 19:747–768
7. Heijnen BJ, Böhringer S, Speyer R (2020) Prediction of aspiration in dysphagia using logistic regression: oral intake and self-evaluation. Eur Arch Otorhinolaryngol 277(1):197–205
8. Kelly AM, Leslie P, Beale T et al (2006) Fiberoptic endoscopic evaluation of swallowing and videofluoroscopy: does examination type influence perception of pharyngeal residue severity? Clin Otolaryngol 31:425–432
9. Hsueh HW, Chen YC, Chang CF, Wang TG, Chiu MJ (2020) Predictors and associating factors of nasogastric tube removal: clinical and brain imaging data analysis in post-stroke dysphagia. J Formos Med Assoc. https://doi.org/10.1016/j.jfma.2020.02.015
10. Humbert IA, Fitzgerald ME, McLaren DG, Johnson S, Porcaro E, Kosmatka K et al (2009) Neurophysiology of swallowing: effects of age and bolus type. Neuroimage 44:982–991
11. Bass N (1997) The neurology of swallowing. In: Groher M (ed) Dysphagia diagnosis and management. Butterworth-Heinemann, Boston, pp 23–33
12. Dehaghani SE, Yadegari F, Asgari A, Chitsaz A, Karami M (2016) Brain regions involved in swallowing: evidence from stroke patients in a cross-sectional study. J Res Med Sci 14(21):45
13. Mosier K, Bereznaya I (2001) Parallel cortical networks for volitional control of swallowing in humans. Exp Brain Res 140(3):280–289
14. Martin RE, Goodyear BG, Gati JS, Menon RS (2001) Cerebral cortical representation of automatic and volitional swallowing in humans. J Neurophysiol 85:938–950
15. Hamdy S, Rothwell JC, Brooks DJ, Bailey D, Aziz Q, Thompson DG (1999) Identification of the cerebral loci processing human swallowing with H2(15) O PET activation. J Neurophysiol 81:1917–1926
16. Lowell SY, Reynolds RC, Chen G, Horwitz B, Ludlow CL (2012) Functional connectivity and laterality of the motor and sensory components in the volitional swallowing network. Exp Brain Res 219:85–96
17. Aho K, Harmsen P, Hatano S, Marquardsen J, Smirnov VE, Strasser T (1980) Cerebrovascular disease in the community: results of a WHO collaborative study. Bull World Health Organ 58:113–130
18. Tatu L, Moulin T, Vuillier F, Bogousslavsky J (2012) Arterial territories of the human brain. Front Neurol Neurosci 30:99–110
19. Brott T, Adams HP Jr, Olinger CP, Marler JR, Barsan WG, Biller J, Spilker J, Holleran R, Eberle R, Hertzberg V (1989) Measurements of acute cerebral infarction: a clinical examination scale. Stroke 20(7):864–870
20. Amitrano A (2018) Dysphagia risk score. Audiologia Foniatria 3:15–16

21. Steele CM, Grace-Martin K (2017) Reflections on clinical and statistical use of the penetration-aspiration scale. Dysphagia 32:601–616
22. O'Neil KH, Purdy M, Falk J, Gallo L (1999) The dysphagia outcome and severity scale. Dysphagia 14:139–145
23. Vose A, Nonnenmacher J, Singer ML, Gonzalez FM (2014) Dysphagia management in acute and sub acute stroke. Curr Phys Med Rehabil Rep 2(4):197–206
24. Suntrup S, Kemmling A, Warnecke T, Hamacher C, Oelemberg S, Niederstadt T, Heindel W, Wiendl H, Dziewas R (2015) The impact of lesion on dysphagia incidence, pattern, and complications in acute stroke. Part 1: dysphagia incidence, severity and aspiration. Eur J Neur 22:832–838
25. Cohen DL, Roffe C, Beavan J, Blackett B, Fairfield CA, Hamdy S, Harvard D, McFarlane M, McLauglinn C, Randall M, Robson K, Scutt P, Smith C, Smithard D, Sprigg N, Warusevitane A, Watkins C, Woodhouse L, Bath PM (2016) Post stroke dysphagia: a review and design considerations for future trials. Int J Stroke 11:399–411
26. Hamdy S, Aziz Q, Rothwell JC, Crone R, Hughes D, Tallis RC, Thompson DG (1997) Explaining oropharyngeal dysphagia after unilateral hemispheric stroke. Lancet 350:686–692
27. Hamdy S, Rothwell JC, Aziz Q, Thompson DG (2000) Organization and reorganization of the human swallowing motor cortex: implication for recovery after stroke. Clin Sci 98:151–157
28. Kim YK, Cha JH, Lee KY (2019) Comparison of dysphagia between infratentorial and supratentorial stroke patients. Ann Rehabil Med 43(2):149–155
29. Kumar S, Doughty C, Doros G, Selim M, Lahoti S, Gokhale S, Schlaug G (2014) Recovery of swallowing after dysphagic stroke: an analysis of prognostic factors. J Stroke Cerebrovasc Dis 23(1):56–62
30. Toscano M, Cecconi E, Capiluppi E, Viganò A, Bertora P, Campiglio L, Mariani C, Petolicchio B, Sasso D'Elia T, Verzina A, Vicenzini E, Fiorelli M, Cislaghi G, Di Piero V (2015) Neuroanatomical, clinical and cognitive correlates of post-stroke dysphagia. Eur Neurol 74(3–4):171–177
31. English KL, Paddon-Jones D (2010) Protecting muscle mass and function in older adults during bed rest. Curr Opin Clin Nutr Metab Care 13:34–39
32. Jardine M, Miles A, Allen J (2018) Dysphagia onset in older adults during unrelated hospital admission: quantitative videofluoroscopic measures. Geriatrics (Basel) 3(4):66
33. Kortebein P, Symons TB, Ferrando A, Paddon-Jones D, Ronsen O, Protas E, Conger S, Lombeida J, Wolfe R, Evans WJ (2008) Functional impact of 10 days of bed rest in healthy older adults. J Gerontol Ser A Biol Sci Med Sci 63:1076–1081
34. Maeda K, Koga T, Akagi J (2016) Tentative nil per os leads to poor outcomes in older adults with aspiration pneumonia. Clin Nutr 35:1147–1152
35. Arreola V, Vilardell N, Ortega O, Rofes L, Muriana D, Palomeras E, Álvarez-Berdugo D, Clavé P (2019) Natural history of swallow function during the three-month period after stroke. Geriatrics (Basel) 4(3):42
36. Mann G, Hankey GJ, Cameron D (1999) Swallowing function after stroke: prognosis and prognostic factors at 6 months. Stroke 30:744–774