SPEECH THERAPY

Pooling score: an endoscopic model for evaluating severity of dysphagia

Pooling score: un modello endoscopico di valutazione della gravità di disfagia

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SUMMARY

The finding of secretions and bolus pooling is of great diagnostic interest in the evaluation of subjects with swallowing disorders. Bedside evaluation alone, in subjects at risk for aspiration, can underestimate this parameter. The usefulness of endoscopic investigation for the evaluation of subjects with swallowing disorders is stressed, in order to plan treatment and follow-up. Based on endoscopic evaluation of material pooling we devised a score expressing the severity of dysphagia. This value takes into account endoscopic landmarks and other parameters of bedside evaluation. Endoscopic and bedside data were collected from a heterogeneous population of 520 consecutive patients seen in our Service over a 6-year period. By means of the *test of equality of group means* and *logistic regression*, parameters able to significantly predict aspiration in the series were identified. An ordinal number was attributed to each parameter in order to obtain scores expressing three degrees of severity of dysphagia: mild, moderate, severe. The scores can be used to guide the management of patients in a simple way, providing indications for targeted referral to the speech pathologist and for tracking the disorder over time. This investigation represents the basis for future research aimed at validating the scores in a larger case series.

KEY WORDS: Deglutition • Dysphagia • Diagnosis • FEES • Aspiration • Pooling • Severity

RIASSUNTO

La valutazione di secrezioni o bolo a ristagno è di grande interesse nella valutazione di soggetti con disfagia. La sola valutazione bedside, in soggetti a rischio di inalazione, può sottostimare questo parametro. Si vuole stressare l'utilità dell'indagine endoscopica nella valutazione di soggetti con disturbi di deglutizione, nella pianificazione terapeutica e nel follow-up. Partendo dalla valutazione endoscopica di ristagni abbiamo realizzato uno score che esprime la gravità di una disfagia. Questo valore considera i soli parametri endoscopici o altri parametri della valutazione clinica non strumentale. Dati della valutazione endoscopica e bedside sono relativi ad un campione eterogeneo di 520 soggetti consecutivi valutati presso il nostro Servizio in circa sei anni. Mediante i test di confronto fra medie e regressione logistica sono stati identificati parametri statisticamente significativi nel predire aspirazione nel campione, come riferito in un nostro precedente lavoro. Un numero progressivo è stato attribuito ad ogni parametro per ottenere degli scores che esprimono tre gradi di gravità di disfagia: lieve, moderata, severa. Gli scores consentono una gestione semplice del paziente, con possibilità di identificare soggetti da avviare al logopedista o seguirli nel tempo. Questo lavoro rappresenta il presupposto di future ricerche per validare gli scores su una casistica più ampia.

PAROLE CHIAVE: *Deglutizione • Disfagia • Diagnosi • FEES • Aspirazione • Ristagni • Gravità*

Introduction

The management of patients with deglutition disorders aims to take charge of patients with dysphagia in different settings [1] according to the criteria of a multidisciplinary team approach. The aim of clinical evaluation is to identify, within the gamut of conditions causing dysphagia, subjects with signs and/or symptoms of dysphagia, to assess the severity of dysphagia (in terms of risk of respiratory complications) and, finally, to give therapeutic options.

As part of the clinical work-up of subjects presenting swallowing disorders [2 3], the assessment of secretions pooling degree provides an important parameter for diagnosing swallowing disorders [4-7] and designing a personal treatment plan. At clinical examination, this sign can be identified by a gurgling voice when collecting the clinical history (due to pooled secretions) or after a challenge with bolus (due to pooled bolus). These clinical findings, in different settings, prompt further instrumental evaluation. Although instrumental follow-up is not always requested, its indication should be noted and justified for medical-legal reasons. In other circumstances, pooling is not documented even with a careful bedside examination (BSE) [3 8-10].

As reported in the literature [3 5 11-15], radiological evaluation may not be the best method for evaluating pooling since it detects only pooling of contrast media (and not saliva or other secretions), and provides a two-dimensional view of bolus that tends to underestimate the amount of pooling.

Moreover, transient observation may not yield sufficient information regarding the fate of the pooled bolus after a swallow. In this context, an attempt has been made, in this investigation, to highlight the importance of evaluating secretion pooling during instrumental examination. A second aim is to correlate this index in a statistical model, including subjective and objective clinical parameters, thus obtaining criteria to judge the severity of dysphagia in terms of the risk of aspiration, expressed as a simple numerical value.

Materials and methods

In a previous study, based on endoscopy evaluation [7], a sample of 520 patients (mean age 67.23 years) from our case series, seen from mid 1998 to 2003, was classified as non-aspirating (378 patients) or aspirating (142 patients). The case series is heterogeneous and includes acute, subacute, nursing home and rehabilitation in-patients and outpatients (stroke, traumatic brain injury – TBI –, chronic cerebrovascular, patients submitted to ENT, neurosurgical and maxillofacial surgery, degenerative neurological disorders, elderly, children). Clinical history was investigated, then the patients were submitted to BSE and fiberoptic endoscopic examination of swallow (FEES) carried out as defined elsewhere [5] and completed with dynamic tests with bolus [5 11 16]. In our experience, performance of FEES requires about 30 minutes. Parameters recorded from the clinical history, BSE and FEES were chosen as with these it is possible to predict aspiration. These parameters (considered as independent variables or factors) are outlined in Table I. The columns refer to the percentage and relative SD, with which each parameter is presented (except for age, where the column shows the mean value), respectively, in non-aspirating pa-

tients, aspirating patients and in the pooled group. In fact, all factors were dummy or binary variables, i.e., 1 for the success or presence of the evaluated condition and 0 otherwise (with the exception of Age, reported as decades). Therefore, the means of dummies represent the proportion of individuals having reported value 1 for the corresponding variable (presence of the condition evaluated). For example, the mean value for collaboration was 0.86, i.e., 86.0% of individuals were collaborating. Moreover, the factors were globally evaluated as significant or non-significant and the results of testing are reported in Table II, where Wilks' lambda statistics are transformed into the F random variable, which is characterised by two degrees of freedom, df1 and df2. In the last column, the corresponding p value is reported, which is the probability of observing a value of F greater than, or equal, to the observed value of F. When the p value is < 0.05, the hypothesis of the equality of the means of the two groups is rejected at the 5% level of significance.

In other words, the *test of equality of group means* (Table II) provides an estimate of the probability of significance (p *value*) for the discrimination between the groups (Sig). Values of $p \leq 0.05$ (shown in bold print) are significant while values $p \geq 0.10$ are not significant. Since this analysis is univariate, borderline values of significance for $0.05 < p < 0.10$ can also be considered. Since the influence of these factors is predictable, their inclusion in the model is unlikely to modify the significance values.

A *logistic regression* was run on the same data (Table III), including all the factors in the model and exploiting automatic selection of the most significant factors by the *backward* method. The recursion was interrupted at the next to last step, to provide a model maintaining the sensation fac-

Table I. Overview of factors.

Factors	Non-aspiration		Aspiration		Pooled	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Collaboration	0.86	0.34	0.64	0.48	0.80	0.39
Gurgling voice	0.07	0.25	0.10	0.30	0.08	0.27
Sensation	0.99	0.07	0.97	0.14	0.99	0.09
Dysarthria	0.21	0.41	0.25	0.43	0.22	0.41
Aphasia	0.08	0.28	0.07	0.25	0.08	0.27
Delayed trigger	0.06	0.23	0.38	0.48	0.14	0.35
Age/10	6.78	1.37	6.55	1.54	6.72	1.42
Sex (0 = M – 1 = F)	0.39	0.49	0.38	0.48	0.39	0.48
TBI	0.02	0.16	0.04	0.20	0.03	0.17
Stroke	0.77	0.42	0.69	0.46	0.75	0.43
Degenerative neurological diseases	0.09	0.29	0.10	0.30	0.09	0.29
Other diseases	0.11	0.31	0.16	0.37	0.12	0.33
Spillage	0.47	0.50	0.54	0.50	0.49	0.50
Cough – penetration	0.12	0.33	0.71	0.45	0.28	0.45
Pooling	0.43	0.49	0.63	0.48	0.48	0.50
Post-swallow dump	0.04	0.19	0.10	0.30	0.05	0.23
Dry swallow	0.37	0.48	0.50	0.50	0.41	0.49

Age is reported as decades and globally evaluated as significant or non-significant.

Table II. Tests of equality of group means for predictor variables.

	Wilks'				
Factors	Lambda	F	df1	df2	Sig.
Collaboration	0.94	33.86	1	518	**0.00**
Gurgling voice	0.99	1.62	1	518	0.20
Sensation	0.99	2.72	1	518	0.09
Dysarthria	0.99	0.78	1	518	0.37
Aphasia	0.99	0.386	1	518	0.534
Delayed trigger	0.83	99.0	1	518	**0.00**
Age/10	0.99	2.70	1	518	0.10
Sex (0 = M − 1 = F)	0.99	0.03	1	518	0.84
TBI	0.99	0.56	1	518	0.45
Stroke	0.99	3.14	1	518	0.07
Degenerative neurological diseases	0.99	0.20	1	518	0.65
Other diseases	0.99	2.81	1	518	0.09
Spillage	0.99	1.94	1	518	0.16
Cough − penetration	0.66	264.68	1	518	**0.00**
Pooling	0.96	17.46	1	518	**0.00**
Post-swallow dump	0.98	8.36	1	518	**0.00**
Dry swallow	0.98	7.75	1	518	**0.00**

Significant values are shown in dark grey, borderline values in light grey [7].
F: random variable. df1-df2: degrees of freedom.

tor (Cough-penetration). The risk of aspiration, in the series examined, includes the following factors in the final model (with the associated levels of significance). This analysis is useful since it not only reveals the factors significantly influencing the differences between the groups characterised by non-aspiration and aspiration, but also provides a tool with which to classify a new subject.

A far as concerns pooling secretion, during the endoscopic evaluation, as reported in our previous studies [5 16 17], the site, amount and management were evaluated. If we consider "pooling" any material that dwells in or coats the hypopharynx and/or larynx cavities, it can be seen that (Table IV):

– site can be described according to anatomical landmarks, with the endoscope in the high and low position: the risk of aspiration increases with pooling in a cranio-caudal direction [6 18]. The lower the site of pooling, the higher the risk of penetration into the lower respiratory tract;

– amount can be defined as the volumetric ratio between content and container namely the degree of coating or filling of the hypopharynx, larynx and cervical trachea. A natural containment cavity (vallecula, marginal zone, pyriform sinus, vestibule, glottis, sub-glottal region up to the cervical trachea) can be coated with pooled material, minimally filled (less than half) or entirely filled, even to the point of overflowing its natural limits. The corresponding values will be 1 for coated, 2 for minimally filled and 3 for entirely filled. During FEES evaluation, pooling may vary [4], increasing, decreasing, or disappear-

Table III. Logistic regression.

Factors	B	SE	Wald	DF	Significance	Exp (B)
Collaboration	−0.79	0.30	6.90	1	0.00	0.45
Sensation	−1.88	1.11	2.83	1	0.09	0.15
Delayed trigger	2.04	0.34	34.76	1	0.00	7.71
Age/10	−0.17	0.08	3.98	1	0.04	0.83
Deg. neurological dis.	−0.96	0.45	4.55	1	0.03	0.37
Cough − penetration	2.77	0.27	103.16	1	0.00	16.01
Constant	1.30	1.25	1.08	1	0.29	3.68

B: Logistic regression coefficient.
SE: standard error.
Wald: Wald statistic.
DF: degrees of freedom.
Significance: probability of significance.
Exp (B): adjusted Odds ratio, impact on the classification outcome [7].

Table IV. Rationale scores based on endoscopic landmarks and bedside parameters with relative values.

Pooling	Endoscopic landmarks		Bedside parameters		
			Sensation	Collaboration	Age (years)
Site	Vallecula	1			
	Marginal zone	1			
	Pyriform sinus	2			
	Vestibule/vocal cords	3			
	Lower vocal cords	4			+ 1 (< 65)
Amount	Coating	1	Presence = - 1	Presence = - 1	+ 2 (65-75)
	Minimum	2	Absence = + 1	Absence = + 1	+ 3 (> 75)
	Maximum	3			
Management*	< 2	2			
	2 > < 5	3			
	> 5	4			
Score	P 4-11			P-SCA 3-16	

P: pooling (value is obtained adding together site, amount and management score).
P-SCA: pooling-sensation, collaboration, age (value is obtained adding together P value to sensation, collaboration and age score).
* Number of swallows required to clear pooling is reported.

ing. The amount of pooling, if initially present, has to be quantified and compared at the end of the tests. This datum has to be correlated with the clinical context but, generally, the most dangerous condition must to be taken into account;

– management is related to spontaneous or reflex activity adopted by the patients to clear pooling: dry swallows, but also gurgling, clearing and cough. In endoscopy, it is possible to observe the reaction of the patient, count the number of dry swallows required to clear pooling (less than 2, between 2 and 5, more than 5) and verify their efficiency. The fate of residues that persist after more than five dry swallows, or after other repeated attempts of removal, is to remain in the cavity for an indefinite amount of time (personal observations).

Based on the previously mentioned statistical model [7], we used some parameters that always reached statistical significance in identifying aspirating subjects (Tables II, III). Other statistically significant parameters, besides the instrumental ones, were collaboration, sensation and age. Collaboration refers, in a wider sense, to consciousness, alertness, fatigability and cognitive abilities. Collaboration is a factor which strongly conditions the clinical evaluation and treatment. Sensation refers to the presence or reduction/absence of any kind of sensibility (protopathic or epicritic) in the cavities of the mouth and pharynx, detected during clinical non-instrumental evaluations [5]. Furthermore, any clinical reaction, up to their absence, to aspiration or to accumulated secretions (cough, clearing, gurgling, dry swallow), can be correlated with the presence or absence of sensibility.

In this respect, we have attributed (Table IV) to the clinical non-instrumental and endoscopic parameters, a progressive number that expresses severity in relation to the risk of inhalation. In detail and in a cranio-caudal direction, a progressive number, as already pointed out, has been assigned for site, amount and management of pooling. The presence of sensation, as a protective condition, is expressed with -1 and the absence with +1; the presence of collaboration, as a protective condition, with -1 and the absence with +1. A further element of risk of inhalation is that of age which we

have quantified considering the average age of our sample (mean age 67.23 yrs) [7]: 1 for age < 65 yrs, 2 between 65 and 75 yrs, 3 for > 75 yrs.

Using this coding scheme, a score is derived ranging from 4-11 for the endoscopic parameters (Pooling score: P-score) and 3-16 with the association of clinical parameters (Pooling-sensation, collaboration, age: P-SCA score) (Table IV). This score comprises four levels, corresponding to the risk of aspiration, considering the minimum level as a normal condition.

P score:
4-5 = minimum score, corresponding to no dysphagia;
6-7 = low score, corresponding to a mild dysphagia;
8-9 = middle score, corresponding to moderate dysphagia;
10-11 = high score, corresponding to severe dysphagia.

P-SCA score:
3-4 = minimum score, corresponding to no dysphagia;
5-8 = low score, corresponding to mild dysphagia;
9-12 = middle score, corresponding to moderate dysphagia;
13-16 = high score, corresponding to severe dysphagia.

The score could refer to mean volumes and specific consistencies of bolus.

In a retrospective analysis, 54 patients of our case series, submitted both to FEES and VFSS, were re-appraised. VFSS was performed with the MBS technique [19]. The parameters considered are those common to the two techniques [20]: spillage, pooling, laryngeal penetration and aspiration. VFSS and FEES tapes were reviewed by three specialists on the team: the phoniatrician, radiologist and speech therapist, all experienced in dysphagia.

Results

In the attempt to calculate scores able to quantify aspiration risk in patients with deglutition disorders, parameters taken from clinical history, BSE and FEES, were considered in 520 consecutive subjects seen in our Unit. The parameters (independent variables) were considered dichotomic.
Final results obtained with the two statistical models used for the analysis and the significance for each parameter are

reported in Tables II and III. At the *test of equality of group means,* the main endoscopic parameters and collaboration were significant, whereas age and sensation were borderline (Table II). At *logistic regression* (Table III), collaboration, sensation and age were significant factors while the parameter cough-penetration was the most reliable of all the endoscopic parameters for explaining aspiration, overwhelming them, including pooling [7].

The statistical models (*test of equality of group means* and *logistic regression*) confirm that endoscopic evaluation identifies aspirating subjects, while BSE contributes with collaboration, sensation and age. FEES offers a very precise visualisation, quantification of pooling and their fate after swallowing. Therefore, it was decided to include pooling, and any reflexive or spontaneous activity related to their presence, in the score.

With the anatomical criteria outlined in Table IV, secretion pooling can be considered alone (P-score), or together with sensation, collaboration and age (P-SCA score). These parameters offer the possibility to obtain a simple value (score) able to quantify the risk of aspiration in subjects with deglutition disorders.

Comparative analysis of data on 54 patients submitted both to FEES and VFSS, showed that only in 2 cases (1 Parkinson and 1 post-ictus) did VFSS document a non-constant intra-swallow inhalation that was not detected with FEES, whereas in 3 patients (2 with ENT and one with cervical spine surgery), a modest post-swallow aspiration was documented by FEES but not by VFSS. For other events (spillage and pre-swallow aspiration), agreement was complete. Albeit, the data did not modify the treatment plan previously designed by the phoniatrician.

Discussion

Secretions or bolus pooling represents the main static parameter of dysphagia. Patients with normal swallowing, as those with dysphagia, adopt swallowing patterns aimed at keeping the food bolus out of the lower airways [21-23]. These patterns adapt to the volume and consistency of the bolus, to achieve the status best suited for protecting the lower airways during passage of the bolus through the pharynx. If we assume that the position of the bolus is the primary trigger for eliciting swallowing and that bolus volume and latency are secondary factors [24,25], sensory or motor defects in dysphagic subjects might compromise the capacity for implementing defensive strategies suitable for protecting the lower airways during swallowing or clearing of bolus from the hypopharynx (from vallecula to pyriform sinus). Furthermore, the variations in swallowing induced by age and the adaptations effected in physiological conditions to maintain a functional deglutition act, should not be overlooked.

Correct and adequate definition of pooling (secretions or bolus) is cardinal for assessing clinical severity and, subsequently, designing a treatment plan. When pooling of secretions is identified at the beginning of the FEES evaluation, the amount may be so severe as to indicate that further execution of the bolus test should not be performed and, moreover, rule out *a priori* the possibility of oral feeding (severe dysphagia) [5,17].

The concept of accumulated secretions, from a clinical profile viewpoint, can be extended to consider all conditions involving deglutition disorders. Thus, we can consider "pooling" salivary secretions, of variable density, that coat the hypopharynx containment cavities or the upper respiratory tract (larynx and cervical trachea), or bolus residue that remain stuck to them after the tests. Secretions in distal sites are a harbinger of more serious clinical conditions, in terms of progression into the lower respiratory tract and the possibility of pneumonia complications [6,18,26]. The ability to adopt defensive strategies (throat clearing, cough, dry swallows), spontaneously or upon request, represents a further element influencing inhalation.

FEES offer the possibility of a direct and optimal evaluation of hypopharyngeal containment cavities, with a precise evaluation of very low quantities of saliva or any other material pooling, without contrast medium. The lower the site of pooling, the greater the risk of aspiration, regardless of the quantity.

The spontaneous reaction induced in the subject by pooling indicates a suitable sensation whereas the effectiveness of the motor strategies activated for pooling removal indicates a suitable neuromotor apparatus. The possibility of prolonged observations allows the clinician to view, at endoscopy, an extremely large number of swallowing acts, with the relative motor and sensorial correlations. In this way, the weakness of the neuromuscular structures can be revealed by a progressive increase in the amount of pooling, their distalization and by the loss of effectiveness of reflexive activities. As already mentioned, in compiling the score, the worst case condition will always be assumed.

The endoscopic evaluation, such as VFSS, detects pre-swallowing events, including aspiration. Post-swallowing events are facilitated by non-deglutitive movements of the structures or by movements of the head and neck or simply by the force of gravity. FEES and VFSS reveal these events [6,20] but if they occur late after swallowing, the radiologic study may miss them. Intra-swallowing events are selectively best evaluated by VFSS: FEES can only indicate, even with extreme precision, indirect signs of the passage of the bolus in the pharyngeal phase (reflex activities and secretions coating the laryngo-tracheal wall).

The criterion of severity obtained with the proposed scores is related to progression into the lower respiratory tract of secretions or parts of the bolus moving through the pharynx. As is well known, this event alone does not necessarily develop into respiratory complications [26]. The present study does not take into consideration patient follow-up but only refers to the possibility of aspiration of secretions moving through or pooling in the pharynx, assigning it a greater clinical severity. Obviously, severity criteria must take into consideration clinical, as well as instrumental aspects, even if the risk of aspiration is never completely predictable. The parameters discussed in the present investigation, refer, even in a simple way, to the evaluation of sensation and collaboration, as clinical events, able to negatively condition the possibility of oral feeding in patients with potentially normal motor abilities. The neuromotor abilities are, again in a simple way, achieved by the efficiency of voluntary or reflexive motor reactions induced by pooling or false route.

In this study, no attempt was made to correlate severity by comparing FEES and VFSS. The potentialities of these approaches are different and relative to pooling evaluation and management, they offer different modes

of evaluation. The only unequivocal piece of data is the presence of pooling (as considered above) and the subsequent possibility of a false route into the lower respiratory tract (before, during or after swallowing) or the possibility of their removal with reflex or spontaneous activities. In patients submitted to evaluations with both techniques, the treatment, planned by FEES was never modified by VFSS.

The P-score and P-SCA score were simplified in order to offer tools to quantify severity, to be easily adopted by phoniatricians and speech pathologists, but also useful for other team specialists and members. The scores allow follow-up of the results of the treatment plan.

Studies are in progress to statistically verify and validate the scores, on a larger case series.

Acknowledgements

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