INTRODUCTION

Deglutition impairments are very frequent in severe traumatic brain injury patients (TBI) admitted for rehabilitation, and account for 25-61% of cases (1-4). There are many underlying causes for swallowing disorders, and related brain injuries generating deglutition system complaints, added to cognition and behaviour impairments, make diagnosis and treatment difficult (5). It must be noted as well that a history of orotracheal intubation and tracheostomy cannulation may cause aspiration (6-9).

Most authors report the most frequent disorder to be a case of impaired oral phase effectiveness and delayed pharyngeal response, with the subsequent risk of aspiration (food matter entering the airways below the vocal cords). In biomechanical terms aspiration may occur before (during the oral phase), after or during the triggering of the swallowing reflex (TSR). The body reacts to aspiration by reflex coughing, with a high percentage of silent aspirators (aspiration induces no coughing) among neurological cases –40 to 60% according to the literature (10-13). Obviously these patients risk an aspiration pneumonia. However, swallowing impairment in TBI patients is apt to respond well, with 75-94% of patients gaining back oral feeding skills (14,15).

Clinical practice entails a variety of diagnoses and therapies for dysphagia in TBI cases. Diagnosis is frequently based on physical examination and external deglutition observation only. However, the assessment of biomechanical impairment needs a videofluoroscopic and occasionally manometric examination (5,12). Videofluoroscopic examination allows for a pathophysiological diagnosis of swallowing dysfunctions and a quantitation of various oropharyngeal apparatus factors, thus permitting a more accurate diagnosis of the deglutition disorder as a basis for eventual specific therapies.

Assessment and early treatment bring major benefits and remove possible complications such as aspiration pneumonia and malnutrition (16). Therefore, the goal of

ABSTRACT

Introduction: swallowing impairments are frequent after severe traumatic brain injury (TBI).

Objective: to define and prospectively quantify the videofluoroscopic symptoms in patients after TBI, and to evaluate the evolution of patients with laryngotraheal aspiration.

Method: we studied 10 patients with TBI, and a clinical suspicion of aspiration confirmed by means of a videofluoroscopic exploration (VDF). VDF was repeated at 1, 3, 6, and 12 months thereafter.

Results: 30% of patients had an impaired gag reflex, and 40% cough during oral feeding. In the first VDF exploration the following was observed: increased oral transit time (OTT) in 70% (average: 3.8 sec.; range: 0.8-15 sec.), altered lingual control in 60%, and dysfunctional palatoglossal closure in 20%. Mean pharyngeal transit time (PTT) was 0.72 sec. (range: 0.34-1.50 sec.), and time to swallowing reflex (TSR) was 0.32 sec. (range: 0.10-0.80 sec.). After one year only 3 patients had aspiration –with a normal OTT in 7 patients, a normal PTT in 9, and a normal TSR in all; 80% had an exclusively oral diet, and 20% combined oral intake and gastrostomy feeding.

Conclusion: videofluoroscopic evaluation allows to confirm and quantify swallowing dysfunction in patients with severe TBI. Most frequent early findings included an increase in OTT and alterations in lingual control; aspirations were quite frequent, and more than half were silent. After one year the majority of patients showed a favorable outcome.


INTRODUCTION

Deglutition impairments are very frequent in severe traumatic brain injury patients (TBI) admitted for rehabilitation, and account for 25-61% of cases (1-4). There are many underlying causes for swallowing disorders, and related brain injuries generating deglutition system complaints, added to cognition and behaviour impairments, make diagnosis and treatment difficult (5). It must be noted as well that a history of orotracheal intubation and tracheostomy cannulation may cause aspiration (6-9).

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Clinical practice entails a variety of diagnoses and therapies for dysphagia in TBI cases. Diagnosis is frequently based on physical examination and external deglutition observation only. However, the assessment of biomechanical impairment needs a videofluoroscopic and occasionally manometric examination (5,12). Videofluoroscopic examination allows for a pathophysiological diagnosis of swallowing dysfunctions and a quantitation of various oropharyngeal apparatus factors, thus permitting a more accurate diagnosis of the deglutition disorder as a basis for eventual specific therapies.

Assessment and early treatment bring major benefits and remove possible complications such as aspiration pneumonia and malnutrition (16). Therefore, the goal of
treatment must be the achievement of a safe, effective, nutritional swallowing free of respiratory disorders.

The aim of this trial was the definition and quantitation of videofluoroscopic disorders in patients after TBI, and an assessment of performance in laryngotracheal aspiration patients.

PATIENTS AND METHOD

A prospective trial was conducted in 10 patients (6 men and 4 women) with severe TBI (average Glasgow coma scale score at injury time of 4, range 3-8) from December 2004 to April 2005, who were admitted for rehabilitation. Mean age was 34 (range: 16-72), and the average time gap from TBI to admission in our hospital was 2.5 months (range: 1-5 months). All patients had a history of orotracheal intubation and tracheostomy cannulation. The clinical suspicion of all having laryngotracheal aspiration was endorsed through videofluoroscopy.

Clinical examination

Deglutition was clinically examined by velopharyngeal reflex assessment (velopalatine and gag reflex), and by giving 3, 5, and 10 ml boluses with pudding, nectar and liquid viscosities (with water thickened by pharmaceutical thickeners –resource thickener), with the occurrence of coughing and/or swallowing-related voice quality changes as endpoints. Examination started with pudding viscosity boluses, which were switched to nectar and liquid viscosities if deglutition was recorded as alteration-free for safety.

Videofluoroscopic examination

The examination was conducted with Gastrografin 3, 5, 10, and 15 ml boluses, with the patient seated and leaning on one side. The full sequence of swallowing was recorded using a Kay Digital Swallowing Workstation (New Jersey, USA). This examination specified the videofluoroscopy parameters assessing deglution effectiveness and safety in both the oral and pharyngeal phases. The examination was conducted with boluses that ranged from pudding to nectar and liquid viscosities. The examination was discontinued if the patient was unable to cooperate or recorded as aspirating.

The endpoints of the oral phase for effectiveness definition were: a) oral transit time (OTT): that is, the time elapsed since the bolus starts moving inside the mouth until the head of the bolus passes by the point where the meets the base of the tongue (in healthy individuals it takes between 1 and 1.25 seconds); b) lingual control: if impaired, the bolus cannot be made and propelled to the back of the mouth and the pharynx. Videofluoroscopy endpoints for oral phase safety assessment were: a) impaired palatoglossal closure: if impaired, the bolus soon falls, partially or totally, into the pharynx (before the swallowing reflex is triggered) and becomes susceptible of aspiration; b) fractional deglutition: this occurs if the patient swallows the bolus split in several pieces (this is considered normal with large boluses, more than 15 ml). Endpoints considered in the pharyngeal phase for swallowing effectiveness assessment were: a) nasopharyngeal regurgitation: this comes from inadequate palatoglossal closure or from a bolus that cannot negotiate the upper esophageal sphincter (UES), which thus goes up into the nasopharynx; b) residue in the pharyngeal cavity after swallowing or build-up of some bolus at the piriform sinuses; c) abnormalities in the UES opening: repletion defects are seen in the pharyngeal back wall and usually called “cricopharyngeal bars”. Videofluoroscopy endpoints considered for pharyngeal phase safety assessment were: a) triggering the swallowing reflex (TSR): when the head of the bolus passes by the point where the jaw meets the base of the tongue, the swallowing reflex is triggered and the pharyngeal phase of deglutition starts, which ends when the tail of the bolus goes through the UOS (considered to be normal below 0.24 sec.); b) pharyngeal transit time (PTT): that is, the time elapsed since when the head of the bolus goes past the base of the tongue until the tail of the bolus goes through the cricopharyngeal region (less than 1 sec. considered normal); c) penetration/aspiration. Penetration is defined as the passage of a bolus into the laryngeal vestibulum above the vocal cords. Aspiration occurs if the food matter goes through the vocal cords into the airways. Additionally, a record was taken of when aspiration took place (before the deglutition reflex was triggered during the pharyngeal or postdeglutition contraction). The occurrence or absence of coughing during aspiration was recorded as well, with silent aspirations defined as those free of reflex coughing.

Patients with manifest aspiration had a new videofluoroscopy examination at 1, 3, 6, and 12 months, endpoints for each examination being OTT, TSR, PTT, and aspirations. Two consecutive aspiration-free explorations meant no more follow-ups needed.

Time endpoints (OTT, TSR and PTT) were quantitated by the 5 ml bolus and nectar viscosity test because this had been the standard for all patients.

Treatment

Patients with a fluoroscopy diagnosis of aspiration had a specific therapy entailing, in cases of predelglutition aspiration, a change in diet features (increased viscosity and decreased bolus size) and postural maneuvering (flexed neck for better airway closure). Cases of aspiration during pharyngeal contraction were treated by changing diet features (increased viscosity and decreased
bolus size), postural maneuvering (flexed neck for better airway closure) and active maneuvering (supraglottic deglutition for better airway closure) if the patient could cooperate. Postdeglutition aspiration cases were prescribed a change in diet features (changed viscosity and decreased bolus size) and active maneuvering (Mendelson maneuver) if the patient could cooperate.

After each videofluoroscopy examination treatment changed according to the aforementioned principles.

Assessment of clinical performance

To assess the effectiveness of treatment strategies for safety problems in swallowing the occurrence of respiratory infections was prospectively researched. Deglutition effectiveness was assessed by analyzing body mass index (BMI) at admission and at 3, 6 and 12 months of evolution.

Feeding modes over one year of follow-up included: normal oral mode (patients had a normal diet), modified oral mode (oral feeding with thickened liquids), oral diet plus gastrostomy feeding (patients had their whole nutritional input per os and liquids by a gastrostomy tube), and gastrostomy tube only.

In our hospital videofluoroscopy is a diagnostic examination tool available in our healthcare practice to assess patients clinically suspected of neurogenic dysphagia. When introduced (1999), this examination procedure was accepted by Institut Guttmann’s Ethics Committee.

RESULTS

The average cognitive function involvement score at admission according to Rancho Los Amigos Cognitive Function Scale (RLCFS) (17) was 4 (range: 2-7) and 7 (range: 6-8) at one year of follow-up (improved neurological response).

Clinical examination of deglutition showed impaired palatine and gag reflexes in 30% of patients, coughing at examination in 40%, and no recorded voice quality changes in patients (not assessable in 60% of patients).

When first assessed, 60% of patients were on nasogastric or gastrostomy feeding, 10% on mixed oral diet and gastrostomy feeding, and the rest on an oral diet only.

Starting videofluoroscopic examination

The analysis of the oral phase in the first assessment gave these results: increased OTT in 70% of cases (average OTT being 3.8 sec., range: 0.8-15 sec.), impaired lingual control in 60% of cases, fractional bolus during deglutition in 60%, and dysfunctional palatoglossal closure in 20%. Findings in the pharyngeal phase were: average PTT of 0.72 sec. (range: 0.34-1.50 sec.), residue build-up at the piriform sinuses in 10% of patients, and impaired UES opening in 10%. Average time to the triggering of the swallowing reflex (TSR) was 0.32 sec. (range: 0.10-0.80 sec.).

The analysis of deglutition time when all 10 aspirations occurred showed that 2 were predeglutition and 9 had happened during pharyngeal contraction (one patient showed both together). Only 4 patients coughed postdeglutition, with 60% thus being silent aspirators. Two patients had penetration into the laryngeal vestibulum.

The texture of the bolus that led to aspiration was liquid in 2 cases, nectar in 6, and pudding in 2 (Fig. 1).

Follow-up showed a progressively normalized quantification of parameters assessing the deglutition function, with decreased OTT, PTT and TSR, and decreased rates of aspirating patients (Fig. 2). Textures that led to aspiration are charted in figure 1.

—Follow-up at month 1. Average OTT was 2.48 sec. (0.34-10); TSR, 0.30 sec. (0.08-0.80) and PTT, 0.72 sec. (0.36-1.36). Six patients aspirated during pharyngeal contraction and one during predeglutition as well (both modes coexisted in this patient); 60% were silent aspirators.

—Follow-up at month 3. Average OTT was 2.03 sec. (0.2-11); TSR, 0.29 sec. (0.1-0.8) and PTT, 0.70 sec. (0.42-1.28). The same number and time of aspirations was kept; 50% were silent aspirators. Twenty percent had penetration into the laryngeal vestibulum.

—Follow-up at month 6. Average OTT was 1.32 sec. (0.34-10 sec.); TSR, 0.25 sec. (0.1-0.8 sec.) and PTT, 0.70 sec. (0.5-1.14 sec.). Five patients aspirated during pharyngeal contraction, and one at predeglutition as well (both modes coexisted in this patient); 60% were silent aspirators. One patient had penetration into the laryngeal vestibulum.

—Follow-up at month 12. Average OTT was 1.32 sec. (0.34-10 sec.); TSR, 0.25 sec. (0.1-0.8 sec.) and PTT, 0.62 sec. (0.4-1.14 sec.). The number of patients recording aspiration decreased so much that only 3 had aspiration (2 during pharyngeal contraction and 1 predeglutition); 30% were silent aspirators. One patient had penetration into the laryngeal vestibulum.

Treatment

After the initial assessment, changes in diet features (increased food bolus viscosity) were prescribed for 80% of patients, postural maneuvering (flexed neck) for 10%, and active maneuvering (supraglottic deglutition) for 10%. Treatment changed upon results after each videofluoroscopy examination, with changed diet features indicated for 50% of patients at follow-up months 1, 3 and 6, and for 30% at follow-up month 12. Postural and active maneuvering were indicated for 10% of patients in all follow-up examinations.
Clinical performance

At one year of follow-up 80% of patients were orally fed (one case was on a modified oral diet and the rest were on a normal diet), and 20% mixed oral intake and gastrostomy feeding. Throughout this time no patient had respiratory infections. BMI at admission was 19.3 (range: 15-22); at month 1, 19.7 (range: 15-24.9); at month 3, 21.3 (range: 16-26) and at one year, 23.2 (range: 20.3-33.2), which implied a BMI increase during follow-up.

DISCUSSION

There are few trials assessing deglutition disorders in TBI patients. The literature reports the incidence of dysphagia to be between 25 and 61% (2,18,19). Variability in results may stem from the concept of dysphagia itself, the method used for assessment, the severity of TBI, and evolution time. Most authors describe a disorder in the effectiveness of the oral phase as the most prevalent complaint in such patients (2,4,16,18).

A trial recently conducted in our unit in patients at the start of severe TBI detected some disorders in the oral phase in 65%, and in the pharyngeal phase in 73% of patients. In the oral phase disorders in deglutition effectiveness prevailed, whereas safety problems stood out in the pharyngeal phase with 75% of aspirations (20).

The series analyzed in this article shows that at month 6 of follow-up half the patients had no aspiration, and that at year one 70% of aspirations have already disappeared. Most aspirations happen during pharyngeal contraction (90%), because of delayed pharyngeal deglutition triggering or defective airway protection during

![Fig. 1.- A chart showing the number of aspiration patients, and the breakdown of viscosities used in the videofluoroscopic examination. Note that in the initial assessment all patients had aspirated liquid, eight nectar, and two pudding as well. At one year of follow-up only one patient had aspirations with all three viscosities.](image)

![Fig. 2.- Evolution of time parameter quantitation and aspiration in the various assessments conducted. Note that at one year of follow-up only three patients still had aspiration, with PTT being normal in all cases, TSR in 9, and OTT in 7. *Parameters (OTT: oral transit time; TSR: time to swallowing reflex; PTT: pharyngeal transit time) compile number of patients with a quantitation within normal range.](image)

Aspiration: 10 Predeglution: 2 Duration: 9

Aspiration: 6 Predeglution: 1 Duration: 6

Aspiration: 5 Predeglution: 1 Duration: 5

Aspiration: 3 Predeglution: 1 Duration: 2

Aspiration: 10

Aspiration: 6

Aspiration: 5

Aspiration: 3

Predeglution: 2

Duration: 9

Predeglution: 1

Duration: 6

Predeglution: 1

Duration: 5

Predeglution: 1

Duration: 2

OTT: oral transit time; TSR: time to swallowing reflex; PTT: pharyngeal transit time) compile number of patients with a quantitation within normal range.
swallowing due to improper airway closure. It should be noted that in 60% of such patients the triggering of the deglutition reflex is delayed. Only one-tenth of aspirations are pre-deglutition because of a failed glossopalatine closure that precipitates the bolus down into the pharynx before pharyngeal deglutition is triggered, with an open airway. In such cases, OTT is substantially lengthened. Additionally, post-deglutition aspirations resulting from excessive pharyngeal residue build-up are susceptible of aspiration during the next inspiration after deglutition (this trial recorded no such case).

A quantitative analysis of deglutition provides an objective measure of several parameters for a more accurate definition of the nature of deglutition disorders, a comparison with other trials, and a more accurate follow-up. This analysis helped us record that over one half of patients followed up have a lengthened OTT, which decreases as the brain injury matures and normalizes in 80% of patients at one year of follow-up. Furthermore, the delayed deglutition reflex triggering at the starting phase eventually normalizes and reaches its normal range between months 6 and 12 of follow-up. Only 20% of patients in this group had a lengthened PTT at initial assessment, with PTT going back to normal in all patients at month 6 of follow-up. It should be noted that improved deglutition function parallels improved neurological function.

The body reacts to aspiration by reflex coughing, but neurological patients include a high percentage of silent aspirators, reported by the literature to be between 40 and 60% (10-13,20). Sixty percent of our patients were silent aspirators at the initial phase of TBI evolution, with a decrease to 30% at year one. The pathophysiological mechanism of silent aspiration is not yet fully specified, although recent trials suggest a dysfunctional mechanism to be involved in the coughing reflex, that is, a peripheral or central injury-related neuromuscular control disorder, a pharyngolaryngeal sensitivity reduction, and a decreased P-substance level (6,21-23).

There is no specific therapy for TBI-related dysphagia (24), though several rehabilitation techniques have been recently advanced (diet, postural and deglutition maneuvers) to compensate for biomechanical disorders (5,11). However, there are very few trials endorsing how effective treatment strategies are to manage neurogenic dysphagia in this group of patients (12,25,26). The most appropriate treatment is based on the pathophysiological mechanism of aspiration and behavioral cognition disorder. The most frequent strategies are those that need no patient collaboration; thus, in over half of cases we change diet components, which is followed by postural maneuvering with little use of active maneuvers based on preserved cognition. Of course, this comes from the fact that the patient must understand how these maneuvers are conducted, thus excluding a high percentage of patients (12,14). However, it should be noted that all these patients, if properly managed from a therapeutical standpoint, can be orally fed (totally or partially) after some follow-up with no respiratory complaints. Therefore, a proper diagnosis and treatment of aspiration during the starting phase of TBI is a must.

Lastly, laryngotracheal aspiration is often apt to happen in patients at the starting phase of severe TBI, with over half of cases being silent aspirators (clinically undetected). Videofluoroscopic examination provides a diagnosis for the pathophysiological mechanism of aspiration, a quantitation of deglutition parameters for a more accurate assessment of oropharyngeal function outcome, and an indication of appropriate therapy for each patient, thus suppressing respiratory complaints and improving nutritional status. On the basis of this initial experience and in light of aspiration outcomes as recorded by videofluoroscopy examination, we recommend that an initial videofluoroscopic check-up be conducted at month 6, and a second check-up one year after the first exploration—subject the patient to minimum radiation—for a better detection of improvements during the course of disease.

REFERENCES