Current aspects of assessment and treatment of dysphagia
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Introduction

Swallowing would appear to be the most normal thing in the world. A healthy person swallows almost automatically. However, normal swallowing is an extremely complicated interplay between various muscles. Timing, coordination, feeling and muscular strength all play a significant role. When this process is disturbed, this can result in swallowing problems (or: dysphagia). Dysphagia is a symptom of many different diseases. In each patient the severity of swallowing problems will be different. Although dysphagia has more than one meaning in medical literature, in this thesis it will be used to describe a specific form: oropharyngeal dysphagia.

Oropharyngeal dysphagia is associated with difficulty in swallowing food and saliva. Frequent problems are coughing while eating and drinking, food getting stuck in the back of the mouth or in some cases, a total inability to eat or drink. This type of dysphagia is commonly associated with a neuropraxia of the muscles involved in swallowing. This neuropraxia can either be the result of a neurogenic disease or the result of surgical procedures (like head-and-neck cancer surgery).

In general, patients with dysphagia can be divided into three groups: patients with neurogenic dysphagia, patients with dysphagia due to head-and-neck cancer and patients with dysphagia due to aging.

After assessment, patients with swallowing problems as described above will in general receive treatment by a speech pathologist, when a medical treatment (such as surgery) is not indicated. This thesis focuses on three aspects of the diagnosis and treatment of dysphagia. This divides this thesis in three sections:

1. The influence of viscosity on the swallowing mechanism in adults;
2. Assessment of the severity of swallowing disorders both from patients’ perspective as from clinicians’ perspective;
3. The effects of treatment of swallowing disorder either with surface EMG biofeedback or with neuromuscular electrostimulation.

In each section of this thesis one or more published scientific articles are presented as an individual chapter. Each chapter ends with a specific and detailed discussion on the specific
research subject. In this final chapter questions about the implications of this thesis on a more general level are discussed. Based on our work, not only recommendations for further research are made, but also for a more effective diagnosis and treatment of dysphagia.

The influence of viscosity on the swallowing mechanism in healthy adults.

*Does thickening of fluids lead to an increase of pharyngeal residue and subsequent to a higher risk for aspiration?*

Aspiration (i.e. food getting into the airway and lungs) might occur in some patients because laryngeal closure has not yet been established when the bolus passes through the pharynx. This allows food or fluids to enter the larynx before it is sufficiently closed. This type of aspiration (known as ‘pre-deglutitive aspiration’) often occurs in patients with dysphagia after stroke as well as in patients with other pathologies. When pre-deglutitive aspiration occurs, the thickening of fluids (with a thickening agent) might be an option to prevent aspiration. As the speed of the bolus is decreased, more time is allowed to establish complete laryngeal closure. Recently, a large trial by Logemann et al. showed that in patients with dementia and Parkinson’s disease (in which pre-deglutitive aspiration is a frequent finding) the thickening of fluids (in combination with changes in body posture) will lead to less direct aspiration. The investigators conclude that in these patient groups the thickening of fluids is a recommended option.

However, one could hypothesise that the increase in viscosity will lead to more pharyngeal residue. This would suggest that the thickening of fluids could result in more pharyngeal residue and thus in a higher risk of aspiration. A study by Perlman et al. showed that patients with severe pharyngeal residue have an increased risk of aspiration. Therefore these patients might acquire an aspiration pneumonia because of aspiration of pharyngeal residue left after the bolus is swallowed. This is called ‘post-deglutitive aspiration’. This type of aspiration is frequently seen in patients with reduced pharyngeal contraction or reduced opening of the upper oesophageal sphincter. For these patients thickened fluids might aggravate their swallowing problems. Normally these patients would get the recommendation to drink thin liquids only. The thickening of fluids as a sole solution for all dysphagic patients seems to be oversimplifying the complexity of swallowing problems.
In our study we investigated the role of viscosity in the build-up of pharyngeal residue. No correlation was found between an increase in viscosity and an expected increase in pharyngeal residue. These findings strengthen the advice to increase viscosity in patients with dysphagia when coughing on thin liquids.

Are there limitations to the methods used in our study to evaluate the influence of viscosity?
Viscosity has been described as the measure of the internal friction of a fluid. This friction becomes apparent when a layer of fluid is made to move in relation to another layer. The greater the friction, the greater the amount of force required to cause this movement, which is called shear. Shearing occurs whenever the fluid is physically moved or distributed, as in pouring, spreading, spraying, mixing etcetera. The force applied to induce shearing is called shear stress. The shearing a liquid experiences is called shear rate. Viscosity can therefore be defined mathematically in the following formula: \( \text{viscosity (} \eta \text{)} = \frac{\text{shear stress}}{\text{shear rate}} \).

In our study we used xanthan which is a polysaccharide commonly used in the food industry. Another frequently used commercial thickener is starch, a polysaccharide carbohydrate consisting of a large number of glucose monosaccharide units. Both thickeners have different shear rates, leading to different results in fluids with similar viscosity. Therefore they might behave differently when exposed to the same stress. Further research should be conducted to explore whether products with the same viscosity but a different shear rate induce the same percentage of pharyngeal residue.

Assessment of the severity of swallowing disorders both from a patients’ perspective as from a clinicians’ perspective.

How can we measure the impact of dysphagia on the Quality of Life in patients?
The SWAL-QoL was developed by McHorney et al. in 2002 as an instrument to evaluate the burden of dysphagia from the patient’s perspective and has been used in many studies since. The Dutch version of SWAL-QoL allows a clinimetrical valid evaluation of the impact of dysphagia on the Quality of Life in Dutch-speaking patients. In the Dutch version of SWAL-QoL none of the subscales reached an internal consistency of 0.95, as is also the fact in the original SWAL-QOL. This allows the questionnaire only to be used on
a group level. Unfortunately this questionnaire cannot be used to evaluate the impact of dysphagia on the Quality of Life in an individual patient.

The SWAL-QoL and its Dutch version (SWAL-QoL-NL) are found to be a reliable tool to evaluate the patients’ perspective in clinical research. Further research however, should be aimed at the development of a Quality of Life-questionnaire for dysphagic patients which can be used on a patient level. This would provide more information to a clinician for therapeutical purposes and will help the clinician to plan tailor-made dysphagia therapy.

Is the clinical evaluation of dysphagia as performed by speech pathologists a reliable tool for detecting aspiration or should a speech pathologist perform a flexible endoscopic evaluation of swallowing (FEES) on each patient with dysphagia?

The evaluation of dysphagia by a speech pathologist normally consists of clinical observations of swallowing, assessment of intra-oral sensibility and a functional examination of musculature involved in swallowing. When a patient is suspected to aspirate, the evaluation by the speech pathologist is normally followed by an instrumental examination like videofluoroscopy or videoendoscopy. Aspiration can be a life threatening condition as an aspirating patient might develop a pneumonia and suffer severe health consequences. A flexible endoscopy or videofluoroscopy is considered to be the gold standard for validation studies of aspiration in dysphagic patients. In 1999 the Agency for Health Care Policy and Research (AHCPR) presented their Evidence Report on the diagnosis and treatment of dysphagia in stroke patients. This report stated that full bedside examinations by a speech pathologist can reach a sensitivity for aspiration near 80% (with a specificity near 70%).

In our study presented in Chapter 5, we showed that in patients with multiple sclerosis the validity of detecting aspiration with help of the routine speech pathology assessment is lower than the sensitivities as stated in the AHCPR-report. With a maximum sensitivity of 53% (with a 95%-confidence interval of 0.40-0.58), the validity of the clinical examination by a speech pathologist in this specific patient group is lower than the 80% sensitivity in the assessment of stroke patients. Our findings show that a reliable assessment tool for stroke patients does not automatically have the same validity in a specific population of patients with multiple sclerosis. This underlines that a thorough validation study is needed.
before any validated assessment tool can be used in another population as which the
assessment tool was validated for.
As a result of our validation study, we found no correlation between one or more of the
outcomes of the different elements of the speech pathology assessment and the risk for
aspiration. As aspiration is a rather frequent finding in this patient group, it is therefore
recommended that a flexible endoscopic evaluation of swallowing (as a gold standard for
detecting aspiration) should be performed routinely in this patient group to evaluate the
risk for aspiration. Further research is needed to evaluate whether these findings can be
extrapolated to the whole population of patients with multiple sclerosis or that our
findings are valid only for this specific subgroup.

The effects of treatment of swallowing disorder either with surface EMG biofeedback
or with neuromuscular electrostimulation.

*Are sEMG biofeedback and NMES suitable therapies for all dysphagic patients?*

Both modalities (sEMG and NMES) aim at a more intensive training of muscles. Therefore
these modalities are only indicated for patients with dysphagia based on weaknesses in
muscles involved in swallowing, and in muscles in which (some) recovery of swallowing
function can be expected based on the medical diagnosis and the evaluation by the speech
pathologist. In patients with degenerative diseases interventions by the speech pathologist
will usually be focussed on compensation and not on rehabilitative exercises.

Since the treatment protocols described in this thesis have a higher treatment frequency
compared to standard treatment, patients should be in such a physical condition that they
can tolerate this frequent and intensive training. Furthermore, both the use of sEMG and
NMES require patient’s cooperation and not too much cognitive impairment.

The use of sEMG and NMES as a treatment modality is contra-indicated in patients with
progressive neuromuscular disorders including peripheral motor neuron diseases, in
patients with a poor physical condition or in patients with impaired cognitive function, as
these patients are not able to fulfil the training. Intensive therapy mainly fatigues muscles
in these patients and would presumably aggravate their swallowing problems.
Neuromuscular electrostimulation is historically seen as a treatment modality aiming at the strengthening of muscles. Therefore, NMES can be considered to be a motor treatment, solely directed at the strengthening of muscle fibers.

However, in more recent publications, researchers are exploring the possible effects of NMES on the cortical organisation of swallowing and the ways NMES affects the cortical planning of swallowing. In 1998, Hamdy et al. showed that 30 minutes of electrical stimulation of the posterior pharyngeal wall in humans leads to increased motor cortex excitability. This stimulation was performed with electrodes placed directly onto the pharyngeal wall with help of a special transnasal catheter and not with skin electrodes which are normally used in NMES. Although this study did not use NMES as a standard method, it started off a scientific discussion on the possible sensory effects of NMES. Following this study, Fraser et al. and Oh et al. published studies in which they demonstrated an increase in corticobulbar excitability with a concomitant improvement of swallowing function in small group of dysphagic patients when using electrodes attached to the neck and chin.

This research into the possible sensory role of NMES in the rehabilitation of swallowing is relatively new, but shows data suggesting that next to the motor component of NMES (aimed at strengthening muscle fibers), a possible sensory stimulation component of NMES might contribute to restoring swallowing function in patients. The exact role of the possible sensory effects of NMES is still under investigation. Based on the current literature it is advised to consider NMES as primarily a motor treatment with possibly sensory effects.

What would be the most optimal stimulation parameters when using neuromuscular electrostimulation in the treatment of dysphagic patients?

Sheffler & Chae suggest that ideal stimulation frequencies for NMES range from 12 to 25 Hz. They also conclude that an increased muscle force generation can be accomplished by a pulse duration of 200μs. However, these optimal parameters have been established for limb muscles, which are histologically different from the head and neck muscles. The question arises whether these parameters would provide the optimal setting for dysphagia therapy.
In 1956, Doty & Bosma\textsuperscript{15} published a study in which they found that the firing frequency of the laryngeal nerves is approximately 30 Hz. This publication supports the use of a low-frequent stimulation when applying NMES in dysphagia treatment. These parameters were also used in more recent studies on the effects of NMES in patients with dysphagia, in which a clear motor response of the neck and submental muscles was found at this frequency in combination with a 200µs phase duration\textsuperscript{16}. Unfortunately no attempts have been published yet to define the optimal stimulation parameters for the use of NMES in dysphagia. Based on the current literature no conclusive statement can be made on the most optimal stimulation parameters when using NMES in dysphagia therapy. However, our findings suggest that a stimulation frequency at 30 Hz with a phase duration of 200 µsec is effective in our study population.

Should speech pathologists be more aware of the influence of treatment intensity on therapy outcome?

In our studies, we used both sEMG and NMES as an adjunct to standard therapy in patients with dysphagia to strengthen specific muscles groups that are involved in swallowing. In our study with chronic stroke patients who were treated with sEMG-biofeedback, treatment intensity can be seen as a confounding factor.

All included patients had received dysphagia therapy at an earlier stage. Some included patients had even performed the same exercises as in our study, but had made no progress in swallowing function. The introduction of sEMG biofeedback in our study not only might have given the patient more muscle control, but also allowed the patient to train his muscles at a more intensive level. Therefore, based on this information, one might conclude that in previous therapy the patient had not been exercising intensively enough to establish any significant changes in swallowing function.

The issue of treatment intensity also immediately arises in any discussion on the role of NMES in swallowing rehabilitation. Chapter 9 of this thesis clearly shows that treatment intensity is a confounding factor in all published articles on the possible effects of NMES in dysphagic patients. Therapists should be aware of the findings by McCarthy \textit{et al.} that consistently indicate that concurrent training of three times a week is optimal for NMES\textsuperscript{17}. The questions on treatment intensity raised in this thesis clearly indicate that more
research should be done on the influence of treatment intensity on the outcomes in dysphagia therapy.

Nevertheless the conclusions in our studies might also indicate that some patients are being undertreated at the moment. In speech therapy many exercises are aimed at muscles strengthening. In the training of speech pathologists sufficient time should be spent on teaching students the basic characteristics of muscle tissue and how muscles can be trained effectively.

What could be the long term (financial) outcome when sEMG biofeedback and NMES are introduced on a large scale in our health care system?

The inability to swallow, and thus the need for tube feeding, has severe consequences for the Quality of Life in patients. In addition, the direct costs annually for a patient to be tube fed in the Netherlands is estimated on around €10,000,- (or €27 daily). This total includes special nutritional fluids, feeding pumps and costs to replace feeding tubes. In the Netherlands in 2007 over 950,000 prescriptions for special feeding and tube feeding were written out according to the Dutch Health Care Insurance Board (CVZ). The total costs in 2007 for tube feeding was estimated to be 31.6 million euros in the Netherlands

Not all 950,000 patients will be eligible for swallowing rehabilitation as described in this thesis, but this number marks the upper boundary of the number of patients which are possible eligible for treatment. Our own conservative estimation based on the assumption will be that 50% of all these patients will possibly be diagnosed with oropharyngeal dysphagia, with concomitant costs of around 16 million euro.

It is difficult to predict the long term outcomes of a more efficient swallowing therapy, as incidence and prevalence rates of dysphagia are not precisely known. The largest patient group with swallowing disorders in the Netherlands is the group of stroke patients. Based on incidence rates from other studies, some predictions can be made into the possible long terms financial effects of swallowing therapy.

Over 30,000 people in the Netherlands suffer from a stroke yearly. More than 50% of stroke patients will have swallowing problems in the acute phase following stroke. Swallowing function will recover in the majority of patients after a period of several months due to spontaneous recovery and swallowing therapy. A large group will not recover from these problems within this period. It is estimated that only 55% of all stroke
patients with dysphagia will return to normal oral feeding within three months. If swallowing does not recover, the patient will have to be fed through a feeding tube. In most cases a percutaneous gastro(jejuno)stomy will be placed by a surgeon. Based on these figures, in the Netherlands yearly around 15,000 stroke patients will receive tube feeding in the acute phase after stroke of which around 7,000 patients (45%) will be tube fed for more than three months. This number will decrease in the months post-onset due to late on-set of spontaneous (and often partial) recovery and as a result of dysphagia therapy. Two studies suggest that 1.5% of all new stroke patients will have to be tube fed for one year and longer.

Unfortunately, it is unknown how much reduction in feeding costs is to be gained in stroke patients who recover from dysphagia within one year. Based on the incidence described above, about 15,000 new patients would be dysphagic for a period up to one year post stroke yearly. The consequent use of NMES or sEMG in this population would most likely lead to a reduction in the total number of days of tube feeding required by these patients. Considering the fact that one day less tube feeding saves €27 per patient per day, the possible savings on feeding costs in dysphagic patients are enormous when the treatment is more effective.

Although tube feeding is necessary to maintain nutritional status, several studies suggest that tube fed stroke patients have a higher mortality than stroke patients who eat and drink. This higher mortality rate is ascribed to a higher incidence of aspiration pneumonia, higher incidence of gastro-esophageal reflux and a higher rate of infections. A decrease in the number of patients being tube fed would therefore possibly lead to a decrease in mortality and an increase in Quality of Life.

Considering the fact that the total number of patients with dysphagia as a result of other neurological disorders, head-and-neck cancer or sarcopenia (i.e. presbyphagia) is most likely to exceed the number of patients with dysphagia after stroke, the costs and cost savings described above therefore should be interpreted as the ‘tip of the iceberg’ of total costs involved in management of dysphagia. Looking at the general trends in health care, it can be expected that in the years to come, the number of patients with dysphagia will rise. With an increase in the incidence and prevalence of dysphagia, the costs involved in the diagnosis and treatment will also rise in the near future.
Our findings suggest that the introduction on a large scale of sEMG biofeedback and NMES in the treatment of dysphagia will lead to a decrease in direct hospital costs, an increase of Quality of Life in patients with dysphagia and a possible decrease of dysphagia related death. However, to estimate the full impact of the introduction of sEMG biofeedback and NMES on a large scale in our health care system, a Medical Technology Assessment with a full cost-effectiveness evaluation based on all relevant utilities would be necessary.

Conclusions and suggestions for further research

This thesis’ aim was to explore current trends in the diagnosis and treatment of dysphagia. Based on our findings four prominent conclusions can be drawn.

Firstly, an increase in viscosity will not lead to more residues in the pharynx, but the precise role of viscosity on the physiology of swallowing remains still unanswered. Further detailed research is needed to explore whether the shear rate is a factor in the build up of pharyngeal residue, not only in healthy volunteers but also in patients. Our findings support that thickening of liquids should be recommended for patients that aspirate when drinking thin liquids.

Secondly, although a valid tool to evaluate the impact of dysphagia on the Quality of Life in different patient groups is now available for the Netherlands, there is still a need for the development of questionnaires for an individual use.

Thirdly, we did not find any correlation between standard speech pathology assessment in patients with multiple sclerosis and the risk for aspiration. Therefore it is recommended that a flexible endoscopic evaluation of swallowing is performed routinely in this patient group to evaluate the risk for aspiration.

And finally, the use of both sEMG and NMES in the treatment of patients with dysphagia can contribute to less mortality, an increase of Quality of Life for these patients and will result in a reduction in direct health care costs.
References


