The use of high resolution manometry for the assessment of swallowing in infants and young children

N. Rommel* and T. Omari**,***

*Department of Neurosciences, ExpORL, Faculty of Medicine, University of Leuven, Belgium; **Centre for Paediatric & Adolescent Gastroenterology, Children, Youth & Women’s Health Services, Adelaide (SA), Australia; ***Department of Paediatrics, University of Adelaide, Adelaide (SA), Australia

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Abstract. The use of high resolution manometry for the assessment of swallowing in infants and young children. Objective: To describe the use and relevance of a novel technique, high-resolution manometry (HRM), to assess the mechanics of deglutition in patients with dysphagia. We present recent insights in the diagnosis of dysphagia in infants and young children through its use. Methodology: Descriptive paper based on literature review and current clinical research. Results: Technical aspects of HRM are described, and pilot data about normal and abnormal swallowing in the paediatric population are presented. Discussion: HRM is the latest development in pressure recording and it is expected that it has high potential for the evaluation of swallowing in the paediatric population. The key advantages relate to the objective nature of the recordings, catheter positioning in the pharyngo-oesophageal segment and the performance of the analysis. Combined measurements with videofluoroscopy and intraluminal impedance for use in children are discussed. Conclusion: HRM makes it possible to describe the biomechanics of the human swallow. Combining HRM with videofluoroscopy in high-resolution videomanometry makes it possible to relate the bolus flow to pressure-flow mechanical terms using objective parameters. The ability to describe the physiological/pathophysiological mechanisms of dysphagia may allow for the development of precise diagnostic criteria for the assessment of swallowing in infants and young children.

ABBREVIATIONS

HRM: high resolution manometry
UOS: upper oesophageal sphincter
MII: multichannel intraluminal impedance measurement

Introduction

Dysphagia is common in the paediatric population and is an obstacle to adequate nutrition for infants and children within a wide range of morbidity. The clinical impact of dysphagia is significant, but the current understanding of pathophysiology is poor and available therapeutic interventions are limited. Before the treatment and management of paediatric dysphagia can commence, a thorough assessment of swallowing function is required. The infant and the adult swallow are quite different and warrant individual discussions in their own right. One cannot assume that assessment techniques that are suitable for adults will also be suitable for babies, infants and children. There are also technical considerations relating to catheter size, sensor spacing and response time which preclude the extrapolation of adult findings to infants and children.

As in any observational method, the quality of information from a clinical examination depends mainly on the examiner’s perceptual skills. If applied properly, instrumental assessment has the potential to document oropharyngeal function objectively. Many different functional tests are available for the assessment of oropharyngeal function during swallowing, each with advantages and disadvantages. Children with dysphagia are typically investigated by videofluoroscopic swallow study. Although helpful clinically, the limitations of the technique in terms of radiological exposure and the lack of measurable objective parameters are well known. At present, the outcomes of videofluoroscopic swallow studies are largely approximate and descriptive.

To make a videofluoroscopy diagnostically more useful, we combined it with a novel high-resolution manometry (HRM) technique to assess pressure changes in the pharynx and upper oesophageal sphincter during
swallowing. The integration of both manometric and videofluoroscopic data in ‘high-resolution videomanometry’ represents a significant advance over a standard videofluoroscopic swallow study for the assessment of dysphagia. This is because it (1) allows quantification of the pharyngeal movements in relation to bolus passage and to the opening of the upper oesophageal sphincter (UOS) and (2) makes it possible to determine the pathological basis for swallowing disorders precisely in terms of abnormal pressure flow patterning across the pharyngo-oesophageal segment. Manometric assessment of swallowing function may help to differentiate in the pathophysiological basis of abnormal swallowing in children with dysphagia and guide the therapeutic intervention.

Materials and methods

1. High-resolution manometry technique

HRM makes it possible to measure pressure along the length of the pharyngo-oesophageal segment using a chain of closely-spaced point-pressure sensors in a high spatial resolution. This allows for the highly accurate spatiotemporal interpolation of dynamic pressure changes caused by luminal closure following contraction. The pressure signals are converted by the intraluminal pressure sensors into an electrical signal which is then recorded and displayed in the form of a multiple line plot or as a ‘colour space-time plot’ (Figure 1). The spatiotemporal plot provides a detailed representation of the space-time pressure structure of the pharyngo-oesophageal segment during swallowing and can be used to define the mechanical properties of the musculature during normal (Figure 1) or abnormal bolus flow (Figure 2).

Recently, HRM has become more accessible and popular as a way of studying dysphagia. High-resolution manometry can be performed using miniature, multi-channel, water-perfused catheters or solid-state catheters. Both perfused and solid-state manometry acquisition systems are commercially available. Pressure dynamics of the pharynx and UOS are difficult to record with conventional manometry due to the rapid response time needed to measure the physiology of the striated muscle of the pharynx. Furthermore, recordings with one or a few side holes are difficult to interpret because of the movement of the UOS during swallowing. Solid-state HRM meets the requirements of rapid response rate and insensitivity to axial movement and is therefore promising in the study of pharyngo-oesophageal motility.

Using HRM to assess swallowing in paediatrics is both different and very demanding. The technical requirements mean that the appropriate manometric devices must have at least 10 pressure sensors spaced at 5-10 mm intervals and the tolerance of the procedure is reduced when the outer diameter exceeds 3 mm. Suitable solid-state catheters have become available...
but they are too expensive for routine clinical use. At present, the most cost-effective option in paediatrics remains water-perfused HRM.

To perform paediatric pharyngeal HRM, we use a silicone rubber water-perfused manometric catheter with closely spaced recording side holes (OD 2.0 mm). The catheter is custom designed depending on the age and study purpose. Up to 16 side holes can be used at 5 mm intervals minimum. The catheter is perfused with degassed distilled water using a low-compliance pneumohydraulic perfusion pump (Dentsleeve, Wayville, South Australia) at 0.04 ml/min per channel. Pressures are registered for each perfused channel using external pressure transducers (Abbott Critical Care Systems, Chicago, IL, USA). Pressure signals are acquired using a computer-based data acquisition system (Trace® v1.2 manometry system, G Hebbard, Royal Melbourne Hospital, Melbourne, Australia). All signals are acquired at a sampling frequency of 25 Hz per channel.

2. High-resolution videomanometry protocol

Approximately 30 minutes prior to the procedure, a manometry catheter is inserted transnasally and positioned straddling the UOS pressure zone. No sedation is required and a lubricant jelly is used to aid the passage of the catheter. There is no evidence that the presence of the catheter alters bolus transit, bolus clearance and/or airway protection. This is also supported by a previous study by Huggins et al.\textsuperscript{13} After the child has grown used to the catheter, he/she is taken to the fluoroscopy suite for a videofluoroscopic swallow study. During videofluoroscopy, the child is placed in an appropriately sized seat. The position of the catheter across the UOS is verified fluoroscopically and
manometrically and altered if necessary. In order to ensure that the swallow test is typical for the child’s feeding, the test is made as ‘child-friendly’ as possible (familiar foods, use of the child’s own utensils and parental involvement are critical). The child is offered boluses with different consistencies depending on the regular diet (i.e. liquid via a bottle or semi-solid/solid using standard utensils that the child is familiar with). Swallows are recorded during video runs of 5-20 seconds each with a total exposure not exceeding 2 minutes, which is standard for videofluoroscopic swallow investigations.

Video images and manometric patterns are acquired simultaneously and stored on one computer using Trace®v1.2 software (Developed by Geoff Hebbard, Royal Melbourne Hospital, Melbourne, Australia). Multiple boluses of the same volume are offered, which may vary from 1-3 ml dependent on the age and oral skills of the child. After the videomanometry, the catheter is removed, cleaned and autoclaved for re-use.

3. High-resolution manometry data analysis

The HRM recordings are analysed using established methods for deriving manometric measures of swallowing. Whereas the colour plot is mainly used for pattern recognition, the line plot serves to measure the exact standard manometry parameters used to describe pharyngeal-oesophageal motility (Figure 3). Depending on the commercial analysis software used, isobaric contour lines may be used which allow the selection of any pressure for identification on the spatiotemporal plot.

The following standard manometric measures of swallowing need to be determined: peak pharyngeal amplitude, pharyngeal propagation velocity, UOS pressure at onset, duration of the UOS relaxation and the UOS nadir pressure. In addition to these standard parameters, a few segmental parameters may be of supplementary value: the peak pharyngeal amplitude at 1, 1.5, 2, 2.5, 3 cm above the UOS and the time between peak pharyngeal amplitude and UOS nadir. This parameter is particularly useful as it describes the coordination between pharyngeal function and UOS opening. In our experience, a lack of pharyngo-oesophageal coordination is often the main cause of dysphagia in our paediatric population.
The patterns of the pharyngeal stripping wave can be classified as antegrade, retrograde or simultaneous based on the sequence of peak pharyngeal amplitudes in time. All described pressures are referenced to resting oropharyngeal (atmospheric) pressure as measured by the second to the most proximal pharyngeal channel in order to correct for the catheter pressure offset during the swallow.

4. Combining HRM with intraluminal impedance for non-radiological assessments

Intraluminal impedance, the inverse measurement of intraluminal conductivity, is an approach that can be used to detect the flow of luminal contents through the gut. When impedance is measured along a segment of the gut using an array of impedance electrodes (multichannel intraluminal impedance, MII), the passage of a bolus of high conductivity (e.g. most liquids and solids) produces a propagated decrease in impedance from baseline. Conversely, the passage of a bolus of low conductivity (e.g. gas) produces a propagated increase in impedance from baseline. A bolus typically produces a pattern of impedance drop followed by recovery to at least 50% of baseline. The impedance wave form can in turn be used to generate a ‘virtual’ display of the bolus passage that is close to the radiological image. This makes it possible to quantify bolus flow and bolus clearance non-radiologically. Initially, we used this technique in relation to understanding mechanisms of gastro-oesophageal reflux and have now applied this technique to the assessment of swallowing. The combined HRM/MII catheter shown in Figure 4 was developed for validating MII against standard videofluoroscopy for the assessment of bolus flow and the detection of failed bolus clearance.

Results

Manometry is particularly helpful in instances where videofluoroscopic imaging shows impaired or absent transit from the hypopharynx to the oesophagus. When this occurs, it may be difficult to distinguish between the failure of the UOS to relax or its inability to open. In this case, failure of the upper oesophageal sphincter relaxation can be documented by manometry, which can provide the differential diagnosis between both causes of dysphagia.

1. Adults

1.1. Pharyngeal-oesophageal manometry in clinical practice

HRM has been successfully applied to studies of the pharynx and upper oesophageal sphincter in adults, either through perfusion or through solid-state technology.

Both pharyngeal swallow function focusing on velopharynx and mesohypopharynx and upper oesophageal sphincter function in healthy subjects have been described recently. The data presented can be used as a reference for clinical solid state manometry studies of swallowing in adults. Normal values and ranges of pharyngeal peak amplitudes, the relaxation interval, median intrabolus pressure, minimum relaxation pressure, deglutitive sphincter resistance and peak pha-
Ryngeal contraction for different swallow volumes are readily available.\textsuperscript{12} At this stage, it is known that HRM facilitates the differentiation between a restrictive disorder and muscular weakness in the pharyngo-oesophageal segment.\textsuperscript{8} Several pathophysiological entities of adult dysphagia still need to be re-explored using HRM. Recently, a new physiological parameter, deglutitive sphincter resistance, has been introduced.\textsuperscript{12} This marker provides an indication of the resistance of bolus flow across the sphincter during UOS opening and is independent of bolus volume.\textsuperscript{12} This might be particularly helpful in clinical diagnostics as many of the patients struggle with the intake of larger boluses. It will be interesting to investigate how this marker behaves during the development of swallowing in our paediatric population.

1.2. Validation of intraluminal impedance for non-radiological assessment of swallowing

In MII studies of healthy adults, we have found that the impedance pattern observed during swallowing correlates well with bolus flow measured by videofluoroscopy, allowing for the accurate calculation of pharyngo-oesophageal bolus clearance time (Figure 5).\textsuperscript{17,19} In adult patients with oropharyngeal dysfunction leading to failure of pharyngeal bolus clearance, there is a good match between radiology and MII in the detection of bolus clearance failure (Figure 6).\textsuperscript{18}

2. Infants and children

So far, mainly because of ethical considerations, the biomechanics of oropharyngeal patterns in normal children have not been determined. Only limited manometric data are available about the pharyngeal and oesophageal phase of nutritive swallowing in children.\textsuperscript{25,26} Achalasia of the UOS in children is rare,\textsuperscript{27} with reports of fewer than 50 cases.\textsuperscript{28} A series of manometrically confirmed UOS dysfunctions in children with VCFS has been reported recently.\textsuperscript{23}

The use of high-resolution videomanometry should be con-
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Considered when paediatric patients aspirate, present with a suck-swallow-breath coordination problem, have difficulty swallowing solids, excessive liquid loss or nasal regurgitation. Its use is not indicated, however, in cases of isolated oral phase problems.

We have performed HRM measurements in healthy preterm infants and in a range of children who were referred for videofluoroscopic swallow assessment. Some of these patients did not have any swallowing abnormality or aspiration during investigation and therefore have been used to establish a database of ‘normal’ values for comparison. Our preliminary findings are presented below.

2.1. Development of pharyngoesophageal motility in healthy preterm infants

Oral feeding capacity in infants depends upon adequate suck-swallow-breath coordination. The swallow consists of the coordination of pharyngeal peristalsis with UOS relaxation and is poorly characterised. Standard manometric assessments of pharyngoesophageal motility has shown few developmental changes in infants with a postmenstrual age of over 32 weeks.

Recently, we assessed the development of the pharyngeal phase of swallowing in healthy preterm infants with HRM. The study included ten preterm infants born at 26-33 weeks gestational age. All the infants were healthy and received full enteral feeding by nasogastric tube at time of oral feeding. The introduction of HRM was performed using a perfused catheter with 8 side holes spaced 5 mm apart. Manometric recordings were made at the first oral

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Figure 6

Detection of failed bolus clearance using impedance. A. Radiological images during swallowing of a 10 ml semi-solid bolus. Three swallows were needed to clear the bolus. B. The impedance pattern produced. Areas of low impedance indicating failed clearance post-swallow are shaded. C. Schematic diagram of bolus flow over time detected by videofluoroscopy and impedance. Each pixel represents a 0.4 sec time interval at each position along the catheter. Shaded pixels indicate bolus presence. In this instance there was significant agreement between the two methods using Cohen’s Kappa statistics ($\kappa = 0.819, p<0.00001$).
feeding attempt and at weekly intervals thereafter for 4 weeks. Data acquisition and analysis were performed using Trace®.

Pharyngo-oesophageal pressures and the timing of events were determined. In total, 360 nutritive swallows were analysed.

Peak pharyngeal pressures during swallowing differed depending on the level of the measurement above the UOS and were age-related. Patterns of pressure wave sequences changed in the proximal pharynx with age. We concluded that the analysis of pharyngeal segments and the timing of motor events using HRM allows the detection of developmental changes in infant pharyngeal physiology. The data indicate that motor mechanisms regulating the pharyngeal component of nutritive swallowing are not fully matured at 31-32 weeks and continue to develop in the period between 31-35 weeks. Immature pharyngo-oesophageal motility may contribute to the incapacity of preterm infants to feed orally.

2.2. Paediatric dysphagia

Bolus flow through the pharyngo-oesophageal segment is dependent on appropriate bolus propulsion, adequate pharyngeal contraction and relaxation of the UOS. These mechanisms may be abnormal in children with dysphagia presenting with severe feeding difficulties. The precise cause of this dysfunction is unclear, but it is likely to be related to the involvement of cranial nerves IX, X or XII, brainstem lesions or to overall depressed central nervous system function.

We have performed pilot HRM measurements in children referred for videofluoroscopy. Table 1 summarises HRM data derived from preliminary studies in five children with an abnormal swallow based on videofluoroscopic swallow assessment and compares these patients with grouped data from patients with a normal swallow.

While all five patients exhibited abnormal post-swallow pharyngeal residues, only one patient aspirated (Patient 3). The primary pathology causing the failure of bolus clearance was pharyngeal in patients 1 & 2. There was manometric evidence in both these patients of low pharyngeal peak pressure amplitudes coupled with abnormally rapid pharyngeal contraction. In these patients, the UOS relaxed appropriately, but to nadir pressures that were typically below normal. The significance of this remains unclear but it would be unlikely that this pattern of UOS relaxation would obstruct bolus clearance.

In patients 4 & 5, failure of bolus clearance was caused by UOS dysfunction and pharyngeal function was normal, suggesting that therapeutic interventions aimed at reducing UOS residual pressure may be successful in improving swallowing effectiveness. The manometric information obtained may help guide the choice of procedure to reduce the UOS high pressure, e.g. dilatation versus myotomy versus Botox injection. In patient 3, the failure of bolus clearance was caused by a combination of rapid pharyngeal contraction and short UOS relaxation. Interestingly, although patients 3 & 5 both were diagnosed with velo-cardio-facial syndrome and presented with an identical videofluoroscopic diagnosis, the manometrically defined cause of swallowing dysfunction was nevertheless different for these patients.

These preliminary data are very encouraging and illustrate how a manometric assessment of swallowing function can help differentiate in the pathophysiological basis for the treatment of infants with dysphagia. The continuation of these studies will enable us to develop precise diagnostic criteria. This will reduce the current trial and error in diagnosis currently confronting carers. The improved understanding of normal oropharyngeal motility may enable clinicians to design more effective therapeutic strategies in cases of abnormality.

Discussion

HRM is the latest development in pressure recording and many expect that it will largely replace traditional manometry for the evaluation of oesophageal/pharyngo-oesophageal function. The most important advantage of HRM over standard manometry is probably that it makes the manometry faster and easier to perform and facilitates the analysis. It was shown that users preferred the spatiotemporal plots for the analysis of manometry data and the colour plot analysis is faster and more accurate than when data are presented than in a line-plot format. Moreover, the spatiotemporal presentation of manometric data is likely to be more easily understood by patients and the “non-expert” physician community because HRM provides the clinician with a more readily interpretable image than traditional manometry.

In our own experience, the topographic plotting of manometric pressures of the infant swallow
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has a specific advantage compared with line plots: it facilitates pattern recognition when studying development and exploring pathophysiology. For example, in our study on the development of the infant pharyngeal motility, it was through visualisation of the consistent low pressure zone in the hypopharynx that the phenomenon was detected and examined. The compressed nature and smaller size of the pharyngeal cavity in the young infant generates a challenge in terms of the correct placement of the manometry sensor at the critical swallow-related structure. In the infant pharynx, spaces between structures are minimal and vary with age. HRM can overcome these dif-

### Table 1

HRM data derived from preliminary studies in five children with an abnormal swallow based on videofluoroscopic swallow assessment, comparing these patients with grouped data from five patients with an asymptomatic swallow.

<table>
<thead>
<tr>
<th>Medical Diagnosis</th>
<th>VF diagnosis</th>
<th>Characteristics of swallow recorded by HRM</th>
<th>Manometric diagnosis</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>UOS parameters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B.P. (mmHg)</td>
<td>R.I. (sec)</td>
</tr>
<tr>
<td>Patient 1 cerebral palsy</td>
<td>No aspiration. Normal bolus propulsion. Pharyngeal residues post-swallow in</td>
<td>Range 30-78</td>
<td>Range 0.4-0.8</td>
</tr>
<tr>
<td></td>
<td>valleculae &amp; piriform sinus prior to initiation of pharyngeal swallow. Pharyngeal residue post-swallow in valleculae and piriform sinus.</td>
<td>37 normal</td>
<td>0.5 normal</td>
</tr>
<tr>
<td>Patient 2 congenital vocal Cord paralysis</td>
<td>No aspiration. Normal bolus propulsion. Pharyngeal residues post-swallow in piriform sinus and on posterior pharyngeal wall. Anterior view shows bolus flow only through right piriform sinus.</td>
<td>36 normal</td>
<td>0.5 normal</td>
</tr>
<tr>
<td>Patient 3 velo Cardio facial syndrome</td>
<td>Aspiration. Pooling of bolus in piriform sinus prior to initiation of pharyngeal swallow. Pharyngeal residues post-swallow in piriform sinus and on posterior pharyngeal wall.</td>
<td>49 normal</td>
<td>0.3 short</td>
</tr>
<tr>
<td>Patient 4 GORD oesophagitis</td>
<td>No aspiration. Insufficient UOS opening during bolus propulsion. Minimal bolus passage beyond the UOS during swallow. Pharyngeal residues post-swallow in the piriform sinus.</td>
<td>82 high</td>
<td>0.8 normal</td>
</tr>
<tr>
<td>Patient 5 veto Cardio facial syndrome</td>
<td>No aspiration. Pooling of bolus in piriform sinus prior to initiation of pharyngeal swallow. Pharyngeal residues post-swallow in piriform sinus and on posterior pharyngeal wall.</td>
<td>57 normal</td>
<td>0.3 short</td>
</tr>
</tbody>
</table>

Abbreviations: Basal UOS pressure (B.P.), UOS relaxation interval (R.I.), UOS relaxation nadir pressure (R.N.), pharyngeal peak pressure (P.P.), pharyngeal contraction velocity (C.V.), pharyngeal intra-bolus pressure (I.B.P.)
culties since multiple pressure sensors are closely spaced and a pressure map along the entire length of the pharyngo-oesophageal segment is provided. The technology eliminates the need for precise positioning of the catheter at the specific swallow-related structures. This is a particularly significant benefit for the study of swallow physiology in infants and children.

As in any type of paediatric motility study, we aim to minimise the invasive nature of the procedure. A possible disadvantage compared to videofluoroscopy is the fact that HRM requires a manometric tube which is obviously more invasive than videofluoroscopy due to the placement of the nasopharyngeal catheter. Clinical experience, however, shows that the insertion and the positioning of a thin and flexible catheter causes no problems and that sedation is not required as interpretable recordings can be obtained with only limited discomfort.

Water perfusion of the pharynx of a patient with dysphagia may involve a potential risk of aspiration and this needs to be carefully considered in every patient. Perfusion at 15 psi leading to a rate of 0.04 ml/min per side hole proved not to cause any inconvenience for the majority of our paediatric patients with dysphagia, probably because this minimal amount of distilled water is swallowed along with the bolus. If the patient struggled with the perfusion, the pneumohydraulic pressures were reduced to 10 psi, which solved the problem in the few cases that occurred.

A major improvement in the placement of the catheter relates to the real-time colour plotting because this visual technique facilitates the placement of the manometric device. Transnasal catheter placement is more easily and accurately performed because of the real-time feedback provided on the computer screen. The immediate visualisation of the pressure recording allows for reliable, fast and easy manometric control of the position of the tube. It does not require difficult, time-consuming pull-through manoeuvres to detect, for example, the high pressure zone of the UOS. In the paediatric population, these methodological improvements may make the difference between success and failure when performing these challenging studies.

The use of the HRM technique to study swallowing often depends on institutional experience, funds and commercial availability rather than any reliance on the clinical and theoretical features. The expense of the equipment, however, is a disadvantage that is likely to be overcome when the technique becomes more widespread.

When the likely underlying cause of pharyngeal dysphagia is being considered in any given patient, Cook has suggested that four fundamental issues should be considered during work-up. Firstly, a correctable structural lesion should be identified if possible. Secondly, any underlying systemic condition that might be treatable in its own right should be identified. Thirdly, the risk of aspiration should be established. Finally, the mechanics of dysfunction should be determined as a precursor to swallow therapy. In the assessment of paediatric dysphagia, it is exactly the latter step that is too often lacking, and this results in the current trial and error in diagnosis experienced by clinicians. In order to overcome this lack of information about the biomechanics of the infant swallow, we started applying HRM to the study of paediatric dysphagia. We were clearly able to recognise a range of pharyngeal and UOS dysfunctions. The pathology varied from simultaneous pharyngeal peristalsis to pharyngeal paralysis, and from a normally relaxing UOS to a poorly relaxing UOS and a non-relaxing UOS (achalasia). In our opinion, HRM is an adequate diagnostic tool for distinguishing the subtle differences between these different pathologies that may be treated by different means. Our experience therefore differs from that of Mahli-Chowla et al. and Rosen et al., who state that manometry of the UOS and pharynx yields little information that changes the management of the patient with upper dysphagia. We take the view that the precise understanding of the nature of UOS dysfunction offered by HRM is an important guide to therapeutic interventions such as UOS dilatation, Botox and myotomy. The pilot studies presented illustrate the value of HRM in identifying the precise cause of abnormal bolus flow during swallowing. We believe that this may help with early diagnosis, improve the accuracy of clinical assessment and lead to more effective treatment for swallowing disorders. Early diagnosis and treatment will prevent secondary behavioural feeding problems in the longer term.

The combination of HRM with videofluoroscopy – ‘high-resolution videomanometry’ – allows the bolus flow to be linked to
pressure parameters. We believe this is currently the best option available in terms of instrumental assessment for paediatric dysphagia. Simultaneous videofluoroscopic control of the bolus flow on top of the evaluation of pressure dynamics has the added value compared to HRM that it allows for the elimination of potential anatomical abnormalities and aspiration risk. In young infants, however, the radiological component of the assessment may be unattainable for ethical reasons. In that case, the pressure profile of the infant may be compared to reference values obtained in healthy preterm infants or in children with an asymptomatic pharyngo-oesophageal swallow. On the other hand, an alternative assessment tool reducing the need for radiology such as multi-channel intraluminal impedance would be very useful for assessment in infants and children.

The use of the MII technique, if proven to be accurate for assessment in infants, has two potential advantages over videofluoroscopy. Firstly, MII does not require the use of ionising radiation to detect bolus flow and bolus clearance. MII may therefore be safer to perform in children, children can be studied over longer periods of time and can be challenged with a greater variety of bolus consistencies/volumes, and there is no need to mix a contrast medium with the food being swallowed. The inability of MII to detect aspiration is a limitation and, clearly, videofluoroscopy will therefore be performed in many patients for this reason. MII may however play a role in the repeat assessment of patients over time following therapeutic intervention.

Conclusion

In summary, objective assessment should be the key point for investigation into the feeding and swallowing abilities of infants and children. With a move away from treating infants as ‘mini-adults’, assessment techniques are now being designed with paediatric requirements in mind.

HRM is a promising technique which allows for the description of the physiological/pathophysiological mechanisms of dysphagia in pressure-flow mechanical terms. The increasingly widespread use of high-resolution manometry has already provided a precise picture of pharyngeal and upper oesophageal pressure patterns of the adult swallow. Knowledge of these objective measures has future potential for guiding the selection, and determining the efficacy, of therapeutic intervention for the treatment of dysphagia in children as well. Current studies with HRM are establishing a picture of the biomechanics of the infant swallow and will improve our understanding of pharyngo-oesophageal dysmotility causing dysphagia. This type of objective diagnostics must continue to be developed in order to meet the specific needs of the paediatric population.

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Dr. Nathalie Rommel
Herenstraat 49 (O&N 2, PO Box 721) 3000 Leuven, Belgium
Tel.: + 32 16 33 04 85
Fax: + 32 16 33 04 86
E-mail: nathalie.rommel@med.kuleuven.be