RCSLT

# High-resolution manometry position paper (draft for consultation)

April 2025

# High-resolution manometry position paper

## Draft for consultation

25th April 2025

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We appreciate any comments provided to us during the consultation, all of which will be reviewed by the working group within the context and scope of the project. We ask that, where possible and relevant, you accompany any counter arguments to statements made in the document with supporting evidence e.g. a research reference.

Members of the working group should not be contacted directly, and all feedback should be made through the assigned route e.g. via survey or project manager. Feedback made through unassigned routes or after the closing date will not be accepted or responded to.

Thank you for your support with this project.

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**Special thanks:**

# Contents

# 1. Practice recommendations

- High-resolution manometry (HRM) is an evidenced based instrumental swallow evaluation and biofeedback treatment tool, suitable for use with service users who present with eating, drinking or swallowing difficulty arising from a wide range of aetiologies in adults and children.
- HRM evaluation may be used as a standalone tool but ideally should be an adjunct to videofluoroscopy or flexible endoscopic evaluation of swallowing to provide further diagnostic information regarding the cause of dysphagia symptoms and to inform treatment planning.
- Following appropriate dysphagia evaluation, HRM has an additional important role in the management of dysphagia as biofeedback tool for compensatory strategies and swallow exercises.
- SLTs are key members of the multidisciplinary team of health professionals working with service users who present with swallowing difficulty. As such, SLTs are optimally placed to promote the use of evidenced based swallow evaluation tools including HRM.
- It is critical that service users are consulted, and their views and opinions considered before deciding to proceed to a HRM evaluation. Service users should be central to any decision-making regarding dysphagia management based on HRM findings.
- As with the use of other instrumental swallow evaluation tools, SLT's involvement in the provision of HRM to service users and the formulation of dysphagia treatment plans based on HRM findings, should take place and be agreed within in a multidisciplinary context.
- Pharyngeal HRM should include contact pressure and impedance measurement
- Depending on competencies attained, the SLT's role with HRM may include:
    - placing the HRM catheter
    - conducting the assessment
    - analysing data obtained from HRM assessment
    - developing treatment plans in conjunction with the service user, their families and the wider multi-disciplinary team
    - leading on use of HRM as a biofeedback tool during treatment
    - screening of the oesophageal stage of swallowing.
- SLT led HRM should follow the latest evaluation guidelines developed by the International pharyngeal HRM working group including number of swallows, bolus sizes and consistencies to assess. The guideline details swallow metrics to include in analysis and diagnostic algorithms to guide treatment. As HRM has a rapidly developing evidence

base, SLTs should maintain an up-to-date knowledge of research and innovations in the field.

- The ability of HRM to provide readily accessible numbers-based measurements of pressure and bolus flow allows analysis of change over time and comparison with established norms. Consideration should be given to how this data can be used within both clinical and research realms to continue to develop and sustain the evidence base around the use of HRM for the management of dysphagia.

# 2. Introduction

The purpose of this document is to describe best practice for the use of High-Resolution Manometry (HRM) as an instrumental dysphagia evaluation and treatment tool by Speech and Language Therapists in the UK.

HRM is an instrumental dysphagia evaluation tool which objectively (Jones et al., 2019a; Ferris and Omari, 2019) measures pressure generation during swallowing with a pressure sensing catheter placed through the nasopharynx and oropharynx and then into the oesophagus (Jones et al., 2019a). Pressure measurements are displayed on a visual plot with warmer colours indicating higher pressures and cooler colours indicating lower pressures (figure 1). Usually, higher pressures are seen during a contraction such as when a swallow occurs, and lower pressures are often seen at rest. Impedance can be added to a standard HRM evaluation to provide additional information on resistance to bolus flow.

Figure 1. Photo of HRM exam with catheter in place and visuospatial plot visible

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**Nashville Speech & Swallowing Specialists, PLLC**

HRM was initially primarily used by gastroenterologists for evaluation of the oesophagus. As an adaptable diagnostic tool with a growing evidence base (Davidson et al., 2020; Davidson and O'Rourke, 2019; Omari et al., 2020) and international consensus (Omari et al., 2020), HRM has more recently been used by a wider range of health professionals. HRPM (High-Resolution Pharyngeal Manometry) is a focused part of HRM, often used by laryngologists and Speech and Language Therapists/Pathologists, to evaluate pharyngeal and upper oesophageal pressure events in relation to bolus transit through the oropharynx (Davidson et al., 2020). As this clinical guideline is informed by the evidence from a range of multidisciplinary professions, terms HRM and HRPM are used. When the evidence base includes the use of Impedance, the terms HRIM

(High-resolution impedance manometry) or HRPIM (High-resolution pharyngeal impedance manometry) or P-HRM-I (Pharyngeal-High Resolution Manometry-Impedance) may be used. When evidence is cited, we have used abbreviations and terms which align with align with those used by the relevant research group. Acknowledging that there are many different abbreviations used, we have included a glossary of terms in this guideline.

Following the lead of our international Speech and Language and multidisciplinary colleagues, this clinical guideline document has been developed to provide information to support the clinical adoption of High-Resolution Manometry by SLTs in the UK. This document sets out the knowledge, skills and training required to achieve competency in HRM and to provide safe, effective and quality care. This document will be of interest to SLTs working with people with dysphagia, service users and carers. The document may also be of interest to other relevant multidisciplinary team members including Radiographers, Gastrointestinal Physiologists, Gastroenterologists, Ear Nose and Throat Surgeons, Respiratory Consultants, Specialist Nurses, Neurologists, Clinical Service Managers, commissioners and researchers.

# 3. Evidence base

## 3.1 What HRM offers in addition to existing swallow evaluation tools

SLTs are at the forefront of providing evaluation and treatment for paediatric and adult service users with difficulty swallowing. Clinical swallow evaluation (CSE) is often the first step in identifying dysphagia and directing management. However, CSE poses some limitations including a high level of variability (McAllister et al, 2016; Brodsky et al., 2016) and difficulty with identifying the predictive risk for aspiration (Virvidaki et al., 2018; O'Horo et al., 2015). The limitations of CSE means that sometimes further evaluation with an instrumental assessment in required. Within the UK, video fluoroscopy swallow studies (VFSS) and/or flexible endoscopic evaluation of swallowing (FEES) are currently the most widely used instrumental swallow evaluation tools by SLTs. Both VFSS and FEES tools have a good evidence base (Virvidaki et al., 2018; Martin-Harris et al., 2020; Giraldo-Cadavid et al., 2022) for swallow evaluation. The use of quantitative measures for both VFSS (Kerrison et al., 2023, Leonard et al., 2024) and FEES (Sutton et al., 2024) is emerging and likely to be developed further as artificial intelligence and machine learning progresses. Currently the interpretation of both VFSS and FEES remains largely subjective. An example of this is the use of VFSS and FEES to hypothesise that physiological impairments such as incomplete velopharyngeal closure, reduced tongue base retraction or impaired pharyngeal contraction are contributing to pharyngeal residue. However, we cannot always tell which of these factors is the primary cause of residue. This can make it more challenging to target effective swallow intervention and to measure change in physiological impairments over time. In contrast to VFSS and FEES, HRM offers the ability to easily collect objective metrics of pressures. These include duration and length of contraction during swallow, intrabolus pressure (pressure exerted by the bolus) and impedance (resistance to bolus flow). Measurements are obtained from sensors placed along the length of the pharynx and oesophagus (Fox and Bredenoord, 2008) using computerised software algorithms (Sweis and Fox, 2020). This enables more accurate hypotheses about physiological impairments including whether velopharyngeal closure, tongue base retraction of pharyngeal contract is the primary factor contributing to pharyngeal residue. This information can help target swallow intervention more effectively. HRM metrics also allow change in physiological impairment of swallow to be measured over time. The wide variety of protocols, catheter configurations, manufacturers, and software in the existing literature poses limits consensus on HPRM normative values (Walters et al., 2024) but some norms are available allowing comparison of non-impaired swallowing with impaired swallowing.

## 3.2 Further evidence about HRM and EDS management

HRM has been identified as an evidence based tool suitable for the evaluation of pharyngeal dysphagia (Omari and Schar, 2018; Hoffman et al., 2012; Bayona et al., 2022; Nollet et al., 2022; Nishikubo-Tanaka et al., 2024; Rommel et al., 2015; Ferris and Omari, 2019; Jadcherla et al., 2021; Damrongmanee et al., 2024) with clinical applications within laryngology (Cheriyan et al., 2023) and speech and language pathology(Knigge et al., 2014). It has particular value as a measure of pharyngeal contractility and upper oesophageal sphincter function (Omari et al., 2025). As a tool which allows visualisation of the pressures generated during swallowing, HRM also has the potential to be used in swallowing therapy as an effective biofeedback tool (O'Rourke and Humphries, 2017; Sibley et al., 2023) and for measuring the effects of compensatory swallow techniques (Mcculloch et al., 2010; Hoffman et al., 2012; Heslin and Regan, 2022; Teplansky and Jones, 2022). In recognition of the growing importance of HRM in dysphagia evaluation and treatment, an international multidisciplinary working group have established a protocol and diagnostic algorithms for disorders of pharyngeal contractility and upper oesophageal dysfunction (Omari et al., 2020; Omari et al., 2025). In most instances, HRM is used as an adjunct to other instrumental swallow evaluation tools which are more effective at determining the extent of aspiration or aspiration risk. HRM may be used as a stand-alone tool in circumstances where VFSS cannot be performed (Omari et al., 2025). Sometimes as an extension to pharyngeal HRM, HRM may be used by SLTs with appropriate competencies as a screen to additionally measure swallow pressures and impedance throughout the length of the oesophagus.

The term ‘high-resolution’ arises from developments in catheter technology, including closer spacing and increased number of pressure sensors within the catheter, compared to previous ‘low-resolution’ manometry (Rosen et al., 2018). Pressure measured by manometry comes from contact pressures generated from the squeeze of the luminal wall on the bolus. This squeeze produces contractility pressures (Rommel et al., 2015).

Measurement of contact pressures alone can provide valuable information regarding pharyngeal contraction during swallowing and relaxation of the upper oesophageal sphincter. However, further development of catheter technology has integrated impedance measurement into a single impedance manometry catheter. Impedance is measured by impedance channels, spaced at approximately 2cm intervals along the length of the catheter. Conductivity between these channels is altered by the presence of a bolus. As an electrically conductive bolus passes between the channels, conductivity is improved, i.e. impedance drops, and the presence of a bolus can be determined. Impedance also measures hydrodynamic pressure. That is the pressure exerted on the catheter from within the bolus as it ‘pushes out’ against the pharynx or upper oesophageal sphincter. This is the concept of distension pressure. High distension pressure is indicative of obstructed bolus flow. Combined impedance-manometry assessment measures contractility and distension in relation to bolus flow within the pharynx and upper oesophageal sphincter and can, therefore, be described as a pressure-flow analysis of swallow function. Inclusion of impedance is particularly valuable in the assessment of upper oesophageal sphincter function as it allows for assessment of the extent of upper oesophageal opening, in addition to the extent of relaxation. Where possible, pharyngeal manometry should be used in conjunction with impedance to provide objective information about bolus position and transit and to facilitate core outcome set measures as recommended by the Leuven Consensus Group (Omari et al., 2025).

High-resolution manometry (HRM) generates a real time visual, spatiotemporal plot which displays time on the x-axis and sensor location on the y-axis (figure 2, Sweis and Fox, 2020). The plot illustrates pressure measurements at different anatomical points including velopharynx, tongue base, hypopharynx, upper oesophageal sphincter and oesophagus. Pressure is represented as changes in colour, with warmer colours indicating higher pressure and cooler areas indicating lower pressure.

The catheter data must be uploaded for analysis by a specialist software programme. Analysis requires the user to first select the swallows and then manually place landmarks to determine anatomical regions and the timing of swallow onset. From this, the software generates numerical data related to swallow contractility, distension and timing, deriving a variety of swallow measurements. This numerical data can be compared with normative data to identify specific areas of dysfunction within the pharynx and upper oesophageal sphincter (Jones et al., 2024). By assessing different bolus sizes and consistencies, it is possible to determine how effectively the swallow modulates and compensates for altered physiology or anatomy and determine the impact on swallow safety and efficiency (Ferris et al, 2021; Sweis and Fox, 2020; Martínez-Guillén et al, 2024).

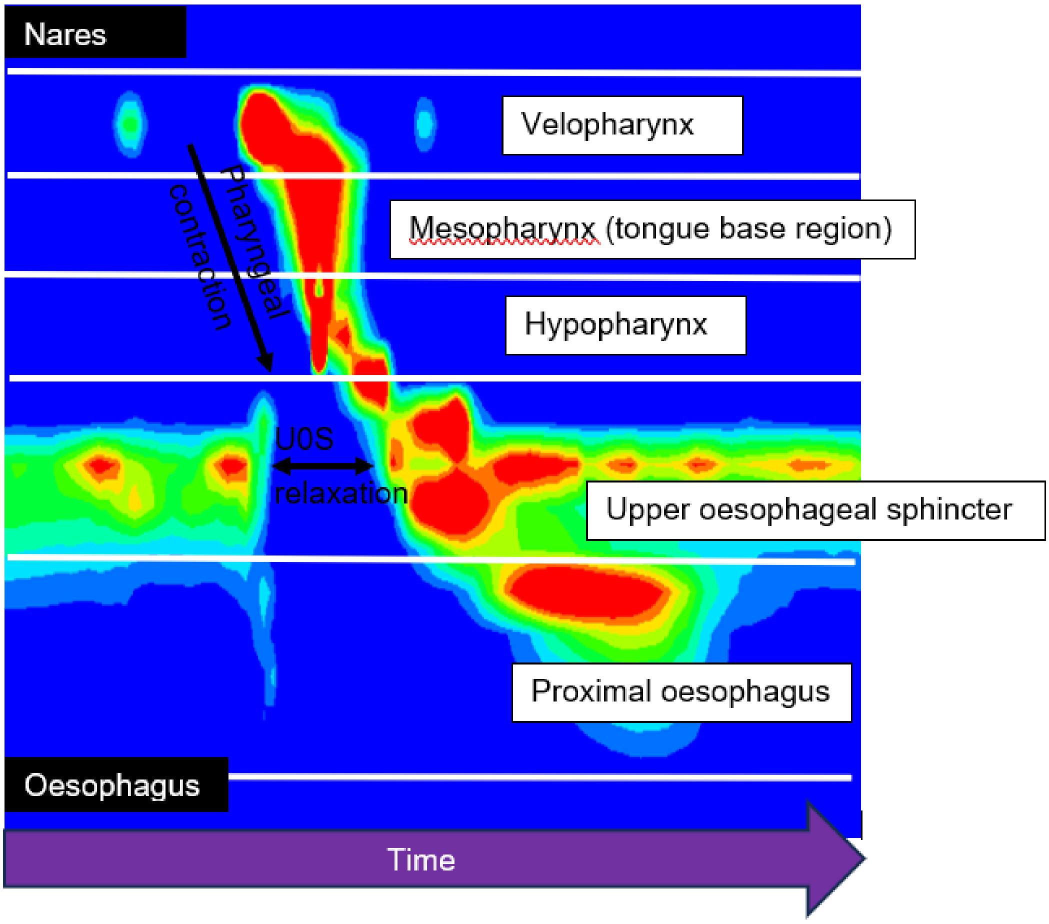


Figure 2. HRM visuospatial (also known as topography or Clouse plot). High pressures are represented as warm colours, low pressures as cool colours. UOS = upper oesophageal sphincter.

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## 3.3 Validity

Validity provides information about how accurately a tool measures what it is designed to measure. As with other instrumental dysphagia evaluation tools, the evidence base around validity for HRM is continuing to develop. Studies which have investigated validity in relation to HRM include a study (Bayona et al., 2022) which compared the diagnostic performance of several physiological pressure and flow measurements with VFSS assessment of aspiration and residue. Findings of this study indicated that some HRPM metrics had diagnostic value in identifying signs of unsafe and inefficient bolus transport finding that aspiration was independently associated with both hypopharyngeal peak pressure and proximal oesophageal contractile HRM measures.

Pyriform sinus residue was independently predicted by hypopharyngeal peak pressure. An innovative study (Kritas et al., 2016) of HRPIM pressure flow analysis in a heterogenous cohort using artificial neural networks was shown to enhance clinically significant swallowing dysfunction potentially reflecting the complex swallow characteristics causing aspiration. A further study (Omari et al., 2023) compared HRPIM measures between participants with dysphagia and controls finding that HRPIM can provide evidence for upper oesophageal sphincter (UOS) disorder based on pharyngeal pressurisation patterns and abnormal findings for UOS relaxation pressure, UOS opening an intrabolus pressure. An important validity study (Szczesniak et al., 2018) identified that intrabolus pressures measured on HRPIM had fair to good accuracy in predicting strictures in participants previously treated for head and neck cancer. In children, those with aspiration on VFSS were found to have lower pharyngeal contractility than those without aspiration (Damrongmanee et al., 2024). Markers of UOS dysfunction have also been shown to differentiate children with and without dysphagia (Ferris et al., 2016; Damrongmanee et al., 2021).

# 3.4 Reliability

Reliability provides information on how accurate a tool is in providing measurement. Inter rater reliability measures the degree to which the people rating the swallow evaluation agree while intra rater reliability measures how consistent each person is when rating the same swallow evaluation with the same tool on different occasions. Test re-test reliability measures the consistency of results when the same tool is repeated on the same subjects over different points in time. In people with head and neck cancer, HRPIM was shown to have better inter-rater reliability for swallow risk index (ICC 0.71) and a swallow residue measures (ICC 0.82) than comparable measures derived from VFSS (Szczesniak et al., 2015). HRM has been identified as a measurement tool with good inter-rater reliability (Fleiss Kappa 0.99 CI 0.967–1.014) for differentiating saliva swallowing and vocalisations events (Ohashi et al., 2023). Another study which investigated reliability of HRPIM in five normal subjects found substantial to excellent agreement on contractility variables, intrabolus pressure and flow timing (intra-rater ICC 0.85–1.00; mean interrater ICC 0.77–1.00) but test re-test results were less reliable (Omari et al., 2016). A further study (Carlson et al., 2018) investigated inter rater reliability for the HRIM impedance metrics of oesophageal bolus flow time and oesophageal impedance integral ratio by two raters across forty subjects. This study found strong ICC 0.873 (CI 0.759-0.933) for median values for bolus flow time and ICC 0.983 (CI 0.968-0991) for median values for oesophageal impedance integral ratio. A paediatric study investigated inter and intra-rater reliability of software generated Chicago Classification and subjective Chicago Classification of thirty paediatric oesophageal HRM recordings analysed by eleven raters using Cohen's and Fleiss kappa (Singendonk et al., 2015).

This study found substantial inter-rater reliability for software-generated Chicago Classification diagnosis after manual adjustment of landmarks (mean κ = 0.69 and 0.77 respectively) and moderatesubstantial for subjective Chicago Classification diagnosis (mean κ = 0.70 and 0.58 respectively). One study (Jones et al., 2014) focused in the investigation of inter and intra-rater reliability among three expert users, fifteen novice users and five Speech Language Pathologists (SLPs) using a semi-automated analysis software programme for thirty HRPM studies. This study found that average inter-rater reliability ICC values across parameters (pressure integrals measured across five anatomical regions) were 0.89±0.11 for expert raters, 0.84±0.15 for novice raters, and 0.86±0.13 for speech-language pathologists. This study additionally found that after a short training session, individuals with little to no prior knowledge of swallowing physiology can perform at a similar level as those with expertise.

## 3.5 Clinical groups

The evidence base supports the use of HRM across a range of clinical groups and service users. HRM may have the potential to be used with a variety of clinical groups including following:

- Stroke (Sung et al., 2018; Lan et al., 2013; Lan et al., 2015)
- Parkinson's Disease (Jones and Ciucci, 2016; Fattori et al., 2022; Ueha et al., 2024; Saleem et al., 2024)
- Myasthenia Gravis (Kumai et al., 2021; Haridy et al., 2023; Kunieda et al., 2022)
- Amyotrophic lateral sclerosis (Takasaki et al., 2010)
- Motor neuron disease (Diver and Regan, 2022)
- Acquired brain injury (Han et al., 2022; Han et al., 2023)
- Head and Neck cancer (Fujiwara et al., 2021; Schar et al., 2022; Komatsu et al., 2022; Umezawa et al., 2023; Schaen-Heacock et al., 2021; Ebersole et al., 2023; Fong et al., 2021)
- Laryngectomy (Lippert et al., 2016; Zhang et al., 2016)
- Anterior cervical spine surgery (Lai et al., 2022)

This is not an exhaustive list but represents the versatility of HRM as a swallow evaluation tool

## 3.6 Safety

Similarly to flexible endoscopic evaluation of swallowing (FEES), HRM is an invasive swallow evaluation tool which involves placement of a catheter trans nasally by a health professional with appropriate training. Potential complications which arise from catheter placement, and which may place service users at risk during a FEES procedure include discomfort, gagging, epistaxis (nosebleed), vasovagal (fainting) and laryngospasm (Nacci et al., 2022). Despite these risks, FEES has been found to be well tolerated by service users with a low rate of complications (Nacci et al., 2022). Consideration should be given to the possibility that service users undergoing trans nasal catheter during HPRM may experience similar risks as those undergoing FEES. Results of a study of one hundred and thirty three participants who underwent HRPIM for the first time found high patient tolerability with low incidence of side effects (Knigge et al., 2019). This study also found that rates of complications and side effects are similar to those reported for other trans nasal procedures. Similarly, HRPIM has been found to be a safe, cotside tool for use in pre-term and term infants (Prabhakar et al., 2019). A large study of adults and children (6-17 years) undergoing oesophageal HRM (n=5017), reported good tolerance in 98.9% of patients(Oh et al., 2023). Intolerance in this study was related to procedural difficulties (such as inability to pass the catheter trans nasally or excessive swallowing) or patient discomfort. Intolerance was higher in children (5.77%) and adults over 80 years (2.43%), compared to adults aged 18-79 years (0,99%). There were no incidences of severe epistaxis, sinusitis, oesophageal perforation, cribriform plate injury, intracranial placement or pneumothorax. It is anticipated that the evidence base around HRM safety will increase as the tool becomes more widely adopted and adverse events are reported within the clinical setting.

## 3.7 Topical anaesthesia use

While many service users will not require application of topical anaesthesia during HRM, in some cases, a person undergoing HRM may require topical application of 2% viscous lidocaine hydrochloride anaesthetic solution in the naris to ease the passage of a catheter. A study of the effect of topical nasal anaesthetic in 20 healthy participants randomised to a placebo or 2% viscous lidocaine hydrochloride group prior to HRM catheter placement, indicated no significant difference in participant comfort(Guiu Hernandez et al., 2018). However, swallowing was affected for the group who received topical anaesthesia, with lower pharyngeal pressure measures found during swallowing. A further study which investigated 20 healthy participants who underwent HRM with impedance on two separate occasions separated by a week having been randomised to a placebo or 2% viscous lidocaine hydrochloride group prior to HRM catheter placement, did not find a difference in comfort levels or pharyngeal and UES swallow measures (Kwong et al., 2022). However, a practice effect was found with improved tolerance of the HRM catheter regardless of topical anaesthesia use during the second HRM session. Another study examined 29 participants each of whom underwent two HRM procedures under two conditions, 5–7 days apart: 2% viscous lidocaine to nares or 0.4 mL 4% atomized and 2% viscous lidocaine to nares(Hernandez et al., 2021). Findings indicated participants preferred atomized lidocaine when undergoing HRM and that this did not affect pharyngeal pressure measurement outcomes.

Medical or pharmacy opinion should be sought prior to use of topical anaesthesia (NICE BNF 2025) (NICE, 2025) and SLTs should seek local advice from pharmacy medicines management on whether a Patient Group Direction (PGD) is required for administration of topical anaesthesia (Medicines Practice Guidelines (MPG2) August 2013 (updated March 2017); NICE, 2017) SLTs can do so only as named individuals (Human medicines regulations 2018; UKParliament, 2018b).

# 4. HRM indications and outcomes

The aim of instrumental swallow evaluation is to identify the cause of swallowing difficulty so that an effective management plan can be formulated and communicated clearly to the service user. This helps support the service user participating in decision making around eating and drinking. Prior to undertaking HRM, a CSE should be completed to determine the nature of the swallowing problem, dysphagia hypothesis, clinical indications, appropriateness and safety. The decision to proceed with HRM should be taken with service user who has been provided with information around the appropriateness and safety of the procedure. In addition to involving the service user, it is recommended that the decision to proceed with HRM takes place within a context of multidisciplinary discussion and agreement. Some service users may benefit from being offered more than one dysphagia evaluation tool to gain comprehensive insights into their dysphagia and to optimise treatment.

As highlighted in the evidence base (Jones et al., 2019b), HRM can be used as an adjunct to more familiar instrumental dysphagia evaluation tools such as FEES and Video fluoroscopy (Sibley et al., 2023). HRM may add important diagnostic information or aid dysphagia hypothesis testing when other instrumental dysphagia evaluation tools prove inconclusive or when the clinical picture is more complex. An interesting paper (Cheriyan et al., 2023) outlines the insights offered by HRPIM for the management of pharyngeal dysphagia. Each of the five cases described outlines the contribution of HRPIM to standard imaging (either VFSS or Endoscopy) in a healthy volunteer, an individual with globus sensation, individuals with a cricopharyngeal bar, and individuals with a previous head and neck cancer diagnosis. In the globus sensation case, HRPIM is described as excluding potential UOS dysfunction or hypertonicity contributing to globus sensation with potential to extend the evaluation into the oesophagus to assess for contributory oesophageal motility disorders such as achalasia or oesophageal spasm. The first cricopharyngeal bar case describes the use of HRPIM to identify that bolus presence time was prolonged with UOS metrics within norms. Impaired lingual bolus control was identified as the underlying contributing mechanism for dysphagia symptoms rather than the cricopharyngeal bar itself. In this situation, information from HRPIM helped guide management away from surgical intervention and towards swallowing exercises and diet modification. In the head and neck cancer cases described, HRPIM is used to distinguish the underlying biomechanical features of dysphagia so that these can be localised to the pharynx or UOS to target treatment appropriately.

## 4.1 Clinical Indications

Suggested clinical indications for undertaking HRM by SLTS in the UK are outlined according to underlying aetiology and suspected or previously confirmed dysphagia signs and symptoms. These clinical indications are drawn from the existing evidence base and are influenced by the findings of a qualitative data study of Speech Language Pathologists in the USA (Jones et al., 2019b). While the latter study highlighted SLPs perception of HRM providing advantages to patient care, there was less consensus on which patient groups are likely to benefit most from HRM. Overall, there was more consensus among SLPs on which patient groups could benefit from HRM and more disagreement about those for whom HRM would be contraindicated. A helpful decision-making tree detailing indications for use of HRM is provided by the International Pharyngeal HRM working group in the Leuven Consensus document (Figure 1, p3, Omari et al., 2025). Please also see International Pharyngeal HRM Working Group – Leuven Consensus suggested indications and contraindications for P-HRM-I for further information on clinical indications (table 1, p4, Omari et al., 2025).

As the adoption of HRM as a dysphagia evaluation tool by SLTs in the UK progresses underpinned by an evidence base, it is anticipated that further consensus on clinical indications will emerge.

## 4.2 Underlying aetiology

As with other instrumental dysphagia tools, HRM may be beneficial to service users across a range of aetiologies. The use of HRM for swallowing evaluation has been described in a wide range of clinical groups. Selected references are included for each clinical group listed below. It is anticipated that the evidence base around the use of HRM will expand in the clinical groups below in addition to developing to encompass further aetiologies.

- Neurological disorders including stroke (Sung et al., 2018), Parkinson's disease (Jones and Ciucci, 2016; Saleem et al., 2024), Myasthenia Gravis,(Kumai et al., 2021; Torres-Barrera et al., 2020) Motor Neuron Disease (Takasaki et al., 2010; Suh et al., 2019; Diver and Regan, 2022)
- Cerebral palsy (Caruso et al., 2022; Damrongmanee et al., 2024; Damrongmanee et al., 2021)
- Trauma including high spinal cord injury (Radulovic et al., 2015) or cranial nerve injury (Nomoto et al., 2021)
- Acquired brain injury (Han et al., 2022; Han et al., 2023; Jensen et al., 2017)
- Head and Neck Cancer (Komatsu et al., 2022; Schaen-Heacock et al., 2021)
- Laryngectomy (Lippert et al., 2016; Zhang et al., 2018)
- Anterior Cervical Spine Surgery (Lai et al., 2022; Lai et al., 2024)
- Chronic cough (Watson et al., 2024; Sykes et al., 2022)
- Globus (Van Daele, 2020)

- Preterm birth (Jadcherla, 2019; Prabhakar et al., 2019)
- Gastro-oesophageal reflux (Rommel et al., 2015)
- Tracheo-oesophageal fistula/oesophageal atresia (Rommel et al., 2015; Ferris et al., 2016; Damrongmanee et al., 2021)
- Laryngeal cleft (Ferris et al., 2016; Baker et al., 2023)
- Congenital cardiac conditions (Ferris et al., 2016)
- Down syndrome (Damrongmanee et al., 2021; Damrongmanee et al., 2024)
- Dysphagia or paediatric feeding disorder of unknown aetiology (Damrongmanee et al., 2024; Ferris et al., 2016)

## 4.3 Dysphagia signs & symptoms

Dysphagia signs and symptoms may be varied resulting in a multitude of co morbidities While not an exhaustive list, the following signs and symptoms of dysphagia may prompt consideration of HRM as either a dysphagia evaluation tool or use within a therapeutic context for biofeedback purposes.

- Clinical signs of laryngeal penetration or aspiration
- Bolus residue
- Globus sensation
- Reports of food sticking or unexplained residue
- Reduced velopharyngeal closure
- Reduced tongue base retraction
- Impaired pharyngeal contraction
- Reduced vocal fold movement
- Presence of cricopharyngeal bar
- UES dysfunction
- Reflux

## 4.4 Dysphagia management

In addition to being used for dysphagia evaluation, data provided by HRM can help direct dysphagia management and assess suitability for surgical intervention. The evidence base for behavioural dysphagia management continues to evolve but there is an increased appreciation that the principles of exercise physiology (Barisic et al., 2011), motor learning (Zimmerman et al., 2020), cortical representation (Martin and Sessle, 1993; Jean, 2001) and neuroplasticity (Robbins et al., 2008) are important for dysphagia rehabilitation. Dysphagia rehabilitation has been influenced by the paradigm shift to incorporate skill based learning in addition to strength (Huckabee and Burnip, 2018, Huckabee et al., 2023) and by improved recognition of the need to individualise therapy according to disease, limits, attitudes, support systems and co-morbidities (Martino and McCulloch, 2016).

The use of biofeedback can help individualise dysphagia rehabilitation by supporting service users in learning compensatory swallow techniques and in tailoring dysphagia exercise regimes. A systematic review and meta-analysis (Benfield et al., 2019) investigating whether therapy with biofeedback improves dysphagia found that dysphagia therapy augmented by biofeedback appears to improve physiological outcome, (specifically hyoid displacement) but translation to functional outcomes was unclear. Several biofeedback tools exist for dysphagia management including FEES (Leder et al., 2004; Kim et al., 2023), surface electromyography (McCullough et al., 2012; Bogaardt et al., 2009) tongue manometry (Robbins et al., 2007; Steele et al., 2013) and digital accelerometery (Reddy et al., 2000).

As HRM provides a visuospatial plot visible to the clinician and service user, it is possible to use this tool to provide proprioceptive training and demonstrate and train targeted swallow interventions (Davidson and O'Rourke, 2019). HRM biofeedback has additionally been highlighted as useful for establishing swallow exercise dosage, monitoring adherence and fatigue and objectively measuring progress (Sibley et al., 2023).

In healthy participants, HRM has been studied as a biofeedback mechanism to guide control of various aspects of the pharyngeal swallow, such as volitional alteration of UES tone (Winiker et al., 2022; Romain et al., 2021), alteration of timing of the pharyngeal swallow (Lamvik et al., 2015). HRM has also been used to provide feedback on timing of pharyngeal swallowing events to patients with known pharyngeal swallow mis-sequencing (Huckabee et al., 2014). HRM has also been described as useful in patients with Parkinson’s disease or those with hypercontractility during swallowing (i.e., muscle tension dysphagia) (Sibley et al., 2023).

In considering candidacy for HRM biofeedback, factors such as adequate cognition, lack of anatomical issues limiting HRM catheter placement and services users ability to tolerate catheter placement for duration of therapeutic intervention need to be considered (Sibley et al., 2023).

## 4.5 Practical indications

HRM does not involve radiation exposure and as the equipment is usually movable, it can be brought to a service user with mobility, positioning or other issues which may preclude transfer to a clinic room. HRM can be conducted concurrently with video fluoroscopy using saline rather than water for barium preparations if impedance measurements are required. Service users with known strictures within the pharynx or oesophagus may not be appropriate for HRM and may require consideration for other dysphagia evaluation tools. Similarly, service users who cannot tolerate invasive procedures or application of topical anaesthesia may not be suitable for HRM and VFSS or FEES or other evaluation tools may be preferred in this circumstance.

## 4.6 Protocol

It is recommended that the protocol developed on majority expert agreement by the International HPRM working group is followed (figure 1, p3, Omari et al.,  2025). The goal of this swallow challenge protocol is to assess pharyngeal swallowing and UES function by capturing a minimum number of tolerated and analysable swallows safely and effectively (Omari et al., 2025). The protocol has been designed to assess swallow function using cued fixed volume fluid bolus challenges ideally consumed in a single discrete swallow (Omari et al., 2025).

It is recommended that at least three trials of any bolus size and viscosity should be given to ensure reliability of measurement. For diagnostic accuracy, boluses of different sizes should be included (5mL, 10mL and 20mL). It is acknowledged that individual variation to the protocol may be required to account for aspiration risk, tolerance and ability to follow instruction (Omari et al., 2025). Boluses can be given in a syringe, or as measured volumes from a spoon or cup (Omari et al., 2025). As the standardised ionic concentration of saline provides better conductivity, saline should be used in preference to water for impedance measurement during HRM (Omari et al, 2020).

Much of the existing evidence base has focused on the presentation of a liquid bolus only. The International Pharyngeal Working Group acknowledges that the Leuven Consensus protocol does not include challenges such as natural sip swallowing or puree and solid food consistencies (Omari et al., 2025). The group highlights that these challenges are potentially relevant to P -HRM-I swallowing evaluation and consider they represent future directions for evidence based research (Omari et al., 2025). Compared to liquid swallows, solid foods and viscous consistencies may be more sensitive in diagnosing motility disorders (Wong et al., 2018). As part of a SLT led HRM evaluation, it may be appropriate to consider the presentation of non-liquid IDDSI framework consistencies (Cichero et al., 2017) individualised to service user preferences and requirements.

## 4.7 Outcomes

The international HPRM working group have recommended a core outcome set of P-HRM-I swallow metrics for the evaluation of pharyngeal contractility and upper oesophageal function (Omari et al., 2025)

- Pharyngeal Lumen Occlusive Pressure: velopharyngeal contractile integral, mesopharyngeal contractile integral, hypopharyngeal contractile integral and hypopharyngeal peak pressure.
- UES Relaxation and Opening: hypopharyngeal intrabolus pressure, upper oesophageal sphincter integrated relaxation pressure, upper oesophageal sphincter maximum admittance, and upper oesophageal sphincter relaxation time.

These metrics are outlined in further detail in International Pharyngeal HRM Working Group – Leuven Consensus Metrics (table 2, p5, Omari et al., 2025).

The International Pharyngeal HRM Working Group have developed consensus recommendations on diagnosis of both pharyngeal contractile dysfunction (figure 8, p12, Omari et al., 2025) and UES dysfunction (Figure 5, p9, Omari et al., 2025).

Additional clinical and process outcomes may include:

- Aetiology and severity of dysphagia
- swallow postures, strategies or manoeuvres
- optimum oral diet recommendations
- further investigations or onward referral including for other instrumental dysphagia evaluation tools
- SLT follow up or discharge
- ENT follow up or surgery

# 4.8 Patient group suitability

HRM is suitable for a wide range of service users (see section 4.1 Clinical Indications)

The following pre procedure checks should be followed:

1. Consent
2. Positive patient identification
    a. Prior to commencing each HRM procedure, service user identification should be checked to ensure that the correct patient is receiving the correct instrumental swallow examination. The process for positive patient identification should then be clearly and appropriately documented. All local NHS policies on positive patient identification should be followed.
3. Food preferences
    a. Patient food preferences should be established prior to the HRM procedure taking place with any food allergies or intolerances identified and documented. This information should then direct the choice of liquids and foods chosen for the HRM evaluation.
4. Allergies
    a. Allergies to medications including Lidocaine local anaesthetic should be established prior to the HRM procedure taking place with allergies documented. This information should then be used to discuss alternatives with the service user including the option not to proceed with HRM procedure.
5. Contraindications (Omari et al., 2025). Please also see, International Pharyngeal HRM Working Group – Leuven Consensus suggested indications and contraindications for P-HRM-I for further information on contraindications (table 1, p4, Omari et al., 2025).

a. As previously outlined, HRM is suitable for a wide range of service users but selection of HRM as a suitable dysphagia evaluation tool must be decided on an individual case basis and through consultation with relevant medical and surgical MDT members.
b. Inability to comprehend or follow instructions or agitation
c. Inability to tolerate manometry catheter due to discomfort or gagging
d. Severe anatomical restriction such as presence of stricture
e. High aspiration risk which cannot be mitigated by controlling bolus size +/- viscosity or by utilising compensatory techniques

Possible contraindications for trans nasal catheter placement for the purpose of HRM include:

- hypersensitivity to catheter placement
- a history of vasovagal or laryngospasm response
- a skull base/ facial surgery or fracture within the preceding 6 weeks
- major or life-threatening epistaxis within the preceding 6 weeks
- trauma to the nasal cavity secondary to surgery or injury within the preceding 6 weeks
- sino nasal and anterior skull base tumours/surgery
- nasopharyngeal stenosis
- craniofacial anomalies
- hereditary haemorrhagic telangiectasia
- choanal atresia
- laryngectomy within the previous two weeks
- presence of pharyngeal or oesophageal stricture or stenosis,
- presence of oesophageal varices

An Ear Nose and Throat (ENT) surgeon should be consulted prior to proceeding with HRM if contraindications are present. For those appropriately trained and competent in the placement of a HRM catheter, an ENT surgeon should be present in situations where placement of the HRM catheter presents more complex challenges. In situations where placement of the HRM catheter poses a risk of harm, the patient should be referred to either an ENT surgeon or Gastroenterologist to ascertain whether the risks of the procedures outweigh benefits for the service user and to ensure safe placement of a catheter.

## 4.9 Considerations for use of HRM in children

High-resolution manometry is well-established as the gold standard tool for the assessment of oesophageal motility in children (Rosen et al., 2018). Its potential in the assessment pharyngeal dysphagia has been recognised for 20 years but technological advancements in catheter technology, specifically the availability of size 6 French 25p12z channel high-resolution impedance-manometry catheters and semi-automated analysis methods, means that it is now an accessible and feasible tool for use in clinical practice (Ferris and Omari, 2019).

Published data to date has demonstrated that HRIM is a safe and reliable method of assessing pharyngeal swallow physiology in preterm and term infants (for example, Rommel et al, 2011; Jadcherla, 2019; Prabhakar et al., 2019) and children up to the age of 18 years (Ferris et al., 2016; Damrongmanee et al., 2021). The principles of assessment and analysis are the same as in adult practice, and thus this position paper should be seen as inclusive of paediatric practice. However, the following considerations are specific to use of PHRIM in infants and children:

1. There is currently no agreed assessment protocol for PHRIM in infants or children. Where possible, the adult protocol should be followed. However, it is acknowledged that this is not suitable for infants or young children. Current recommendations are for inclusion of both single swallows and consecutive swallows (bottle/breast/cup) (Jadcherla, 2019) and inclusion of a minimum of three swallows of IDDSI 0 and IDSDI 4 (if developmentally appropriate) across two developmentally appropriate bolus sizes (Ferris and Omari, 2019).
2. Manometry is generally well-tolerated in typically developing children up to 18 months of age and older than 5 years of age. Careful consideration is required, including discussion with caregivers, to determine the cost/benefit for children aged approximately 18 months-5 years and those with sensory-based feeding difficulties or avoidant/restrictive food intake disorders (Ferris and Omari, 2019).
3. Age-appropriate explanations of the procedure and calming strategies should be used for all infants and children undergoing PHRIM.
4. The availability of normative data for children is very limited and will continue to be hindered by ethical issues restricting study of 'healthy' infants and children. Differences in pharyngeal contractility and upper oesophageal sphincter metrics have been seen in children of different ages, between preterm infants and older children and children and adults (Damrongmanee et al., 2021). Therefore, caution is warranted in direct application of adult normative data to children. Given these limitations, pHRIM should not be considered a standalone instrumental assessment of swallowing in children at the present time.

# 5. Equipment, personnel and environment

Equipment required includes a HRM stack on a moveable trolley with a monitor to display the visuospatial plot during the examination. The system must include software to record, analyse and archive exams. Additional equipment required is a HRM (preferably with impedance) catheter(s). Either pharyngeal or oesophageal catheters can be used. If using an oesophageal catheter, this should be placed initially with the uppermost sensors at the velum, to ensure the full length of the pharynx is evaluated. If oesophageal evaluation is also being conducted, the catheter may need to be repositioned to ensure the distal sensors are sited within the stomach. The HRM catheter should be prepared with a water based lubricant prior to insertion (Knigge et al., 2019). All HRM catheters have a limited lifespan of approximately one hundred uses so when preparing a business case for HRM, it is helpful to budget for at least two catheters. As catheters sometimes require repair, it is also important to make provision within business cases for a budget for a maintenance contract for the HRM system and catheters. HRM consumables should be readily available to minimise duration of the evaluation and oral trials should be tailored for each individual. HRM equipment and catheter should be cleaned between service users, in line with local infection control policy. Suction, oxygen and resuscitation equipment may need to be readily available in case of significant aspiration or respiratory compromise during HRM evaluation. In some situations, it may be appropriate to have pulse oximetry equipment available to monitor patient oxygen saturation levels. Local health and safety policies should be reviewed and followed.

## 5.1 Personnel

A minimum of two persons is required to safely and effectively carry out HRM. One is required to pass the catheter, operate the HRM equipment and software. The other individual is required to perform the assessing/interpretation role and to assist with presentation of oral trials. Ample time should be allowed for HRM with this varying across different clinical settings.

## 5.2 Environment

HRM should be performed in an appropriate clinical treatment setting, which may mean a hospital ward, a rehabilitation unit or a designated clinic. All environments should be risk-assessed. All settings for HRM procedures should be both RCSLT HRM clinical guideline compliant and locally compliant for optimal patient safety.

## 5.3 Infection control and decontamination

Disease transmission is possible during HRM via contact with equipment contaminated by saliva, blood and other bodily fluids. It is essential that a robust method of effective decontamination is agreed with service commissioners, with appropriate risk assessments documented. Decontamination and storage of clinical equipment should adhere to universal and local trust policies, and to guidelines on infection control and decontamination of trans nasal catheters.

## 5.4 Disposal of trial foods and fluids

All foods and fluids used for oral trials should be disposed of appropriately at the end of the procedure in accordance with local infection control policy.

## 5.5 Incident reporting

Any complications or adverse events observed during HRM should be immediately and accurately reported using local incident reporting systems, and incidents should be logged and audited annually to ensure safe practice and learning outcomes.

## 5.6 Resuscitation

Because of the invasive nature of HRM SLTs involved in performing the examination must undergo regular basic life support and CPR training that is delivered locally. Additionally, SLTs involved in HRM should have knowledge of how to manage vasovagal or laryngospasm responses, and knowledge of managing epistaxis.

## 5.7 Ethical considerations

In addition to clinical indications and practical considerations, a decision to proceed with HRM should be based on the potential impact of recommendations and outcomes on the patient's quality of life. SLTs should consider HRM in the context of insight, the patient's desire to eat and drink, capacity, wishes, mood, cooperation, fatigue, distress, comfort, health status and prognosis. The benefits of HRM should outweigh the risks. HRM findings should be interpreted within the wider patient context and contribute to decision-making by the MDT, on matters such as the safety of oral feeding and likelihood of negative health consequences, such as aspiration pneumonia.

## 5.8 Professional boundaries

HRM should always be performed in a multidisciplinary team context. As with other instrumental dysphagia evaluation tools, it is not the role of SLTs to make medical diagnoses. SLTs use HRM to evaluate pressure generation during swallowing and to direct further management to optimise swallow function. Additionally, SLTs may also use HRM as a biofeedback tool for compensatory swallow manoeuvres and during exercise-based swallow therapy. Advice should be sought from relevant multidisciplinary medical and surgical team members should any structural or other abnormalities be noted during the evaluation.

# 6. Clinical Governance

## 6.1 Patient information

It is good practice to provide online, verbal and, where possible, accessible written information about the HRPIM procedure and possible effects prior to the examination. An information leaflet and should be available and access to an interpreter arranged for the procedure, if required.

## 6.2 Legal framework and consent

Consent should be informed, specific, unambiguous, given freely and involve clear affirmative action and referring to Good Data Protection Regulation (UKParliament, 2018a). When a decision for HRM is made, it should be explained that HRM is a minimally invasive procedure carrying low risk, and informed verbal consent should be obtained. The SLT involved in HRM should ensure that consent is still valid before the examination begins referring to the UK legal framework for consent (UKGovernment, 2009). Consent procedures should be in accordance with local and/or best practice guidelines. Where the patient is deemed to lack mental capacity to give or withhold informed consent, proceeding with HRM may still be appropriate, if considered clinically necessary and in the patient's best interests. Decisions are governed by legalisation and should be taken under advice and within the context of the MDT. Legislation to be considered includes UK regulation on consent (UKGovernment, 2009), Mental Capacity Act UK (UK Parliament, 2005), Mental Capacity Act Northern Ireland 2016 (NI Assembly, 2016); Adults with Incapacity (Scotland) Act 2000). A HRM procedure should be aborted at the point at which a patient indicates a withdrawal of consent or refusal, i.e. pulling out the catheter. Consent should be obtained to record HRM results and visuospatial plots. If materials saved from HRM evaluations are to be used for teaching, audit or research, service users must be aware that they can refuse without their care being compromised and that they can be anonymised (UKParliament, 2018a). Sensitive health data, including photographs should be processed confidentially according to local and national guidelines and data protection regulation (UKParliament, 2018a).

## 6.3 Duty and Standards of Care

The SLT has a duty of care to reduce harm and to share HRM swallow evaluation patient data with other healthcare professionals to ensure safe and effective treatment (Health & Social Care Safety and Quality Act 2015, UKParliament, 2015; Health and Care Act 2022, UKParliament, 2022). SLTs should ensure that they apply the recommended standards of care to all HRM dysphagia evaluation activity. This includes working within the limits of their HRM and dysphagia knowledge and skills, managing risk, reporting safety concerns, promoting and protecting the interests of service users, respecting confidentiality, communicating appropriately and keeping accurate records (HCPC Standards of conduct, performance and ethics 2024, Health and Care Professions Council, 2024) .

## 6.4 Rating and reporting

HRM systems have an integrated software programme which will generate swallow metrics and a report. Standard detailed HRM reports, including images of visuospatial pressure plots, are recommended for consistent reporting and should be available to the multidisciplinary team. Reports should be completed in a timely manner. Reporting should be carried out contemporaneously and findings documented within the medical notes. Any complications should be documented and communicated with relevant medical staff.

# 7. Audit and research

## 7.1 Audit

HRM outcomes should be audited for clinical efficacy and/or impact on the quality, safety and cost of patient care. This will provide vital information on the added value of speech and language therapy interventions. Quality improvement frameworks can be used to support the further development of HRM and dysphagia services. HRM data may be shared with other SLTs and professionals through networks in order to support the wider establishment of HRM services. Safety should be monitored through regular audit of adverse effects, and changes made to practice reducing risks, if these are occurring more frequently than reported in the literature.

## 7.2 Research

There is still wide scope for research in HRM particularly in the UK where HRM is an emerging instrumental dysphagia evaluation tool. SLTs are encouraged to develop patient centred and clinically relevant projects, which build the evidence base around HRM to improve functional swallow outcomes. The following research priorities are recommended:

- developing HRM normative data based on a UK population across paediatric and adult populations
- developing paediatric protocols for conduct and analysis of HRM
- developing a protocol for HRM swallow evaluation which includes non-liquid food consistency challenges and other functional swallow challenges including repeated cup sip drinking
- developing a protocol for screening oesophageal swallow with HRIM by SLTs

- understanding how to use HRM swallow metrics to outcome cued fixed volume swallow challenges in populations unable to perform a single discrete swallow
- understanding patient and caregiver experience and satisfaction with HRM as an evaluation and feedback tool
- investigating the impact of swallow compensatory strategies on functional swallowing performance using HRM measurement
- investigating the feasibility of HRM for measuring impact of behavioural and surgical swallow interventions techniques on dysphagia
- comparing diagnostic yield of HRM with other instrumental dysphagia evaluation tools in relation to identification of swallow impairment
- using HRM to define swallow physiology in specific populations

# Appendices

## Appendix 1: Process for the production of HRM position papers by RCSLT

### Process

A project proposal form was submitted to RCSLT in Spring 2023 outlining a project with the following objectives

(i) Develop an evidence based clinical guideline for the use of HRM for the evaluation and treatment of dysphagia by UK Speech and Language Therapists

(ii) Develop an evidence-based competency framework for the use of HRM for the evaluation and treatment of dysphagia by UK Speech and Language Therapists.

The project proposal form included suggestions for expert multidisciplinary colleagues in the UK and internationally who could be approached to support the project.

Subsequently, a HRM working group was convened which approved a scoping document for the RCSLT HRM project. The working group agreed to support the development of a HRM clinical guideline and competency document for the RCSLT members.  A service user group panel was established to work alongside working group members to develop and inform relevant documents.

### Scoping the literature

A literature review was undertaken to identify and appraise relevant HRM research. This work informed the development of the clinical guideline and competency document to ensure each is underpinned by an evidence base. It is beyond the remit of this document to include an extensive systematic review of HRM.

### Writing

The clinical guideline and competency document was developed by the lead author Margaret Coffey with support from working group members. Alex Stewart led on both the paediatric evidence review and writing for the paediatric sections of this document.

### Consultation

The RCSLT membership, board members, relevant Clinical Excellent Networks (CENS), international experts and wider stakeholders including service users were invited to take part in the consultation process. Working group members evaluated all feedback, made amendments as appropriate and recorded all decisions for approval or rejection of comments.

# Abbreviations

RCSLT – Royal College of Speech and Language Therapists

SLT – Speech and language therapist

HRM – High resolution manometry

HRPM – High resolution pharyngeal manometry

HRIM – High-resolution impedance manometry

HRPIM – High-resolution pharyngeal impedance manometry

PHRIM – Pharyngeal high-resolution impedance manometry

P- HRM-I – Pharyngeal-high resolution manometry-impedance

UOS – Upper oesophageal sphincter

UES – Upper esophageal sphincter

VFSS – Videofluoroscopic swallow study

FEES – Flexible endoscopic evaluation of swallowing

PGD – Patient group direction

MPG – Medicine practice guidelines

NICE – National Institute for Health and Care Excellence

BNF – British national formulary

IDDSI – International dysphagia diet standardisation initiative

MDT - Multi-disciplinary team

ENT – Ear, nose and throat

CPR – Cardiopulmonary resuscitation

CENS – Clinical excellence networks

UK – United Kingdom

# Glossary

| | |
|---|---|
| High-resolution manometry | Catheter-based assessment of contact pressures generated by muscle contraction or relaxation. |
| Pharyngeal high-resolution manometry | Catheter-based assessment of contact pressures generated by muscle contraction or relaxation in the pharynx, upper oesophageal sphincter and proximal oesophagus. |
| Oesophageal high-resolution manometry | Catheter-based assessment of contact pressures generated by muscle contraction or relaxation in upper oesophageal sphincter, oesophagus and lower oesophageal sphincter. |
| High-resolution impedance manometry | Catheter-based assessment of contact and hydrodynamic pressures. Hydrodynamic pressure is pressure generated from bolus contact with the catheter, which indicates presence of a bolus. Impedance manometry is recommended for pharyngeal assessment. |
| Topography plot, visuo-spatial plot or Clouse plot | Visual representation of contact pressures generated by HRM. The warmer the colour, the higher the pressure. The cooler the colour, the lower the pressure. The spectrum runs from blue (lowest pressure) to red (highest pressure). |
| Bolus conductivity | To aid bolus visualisation and enable comparison with normative data, conductivity is standardised by adding XX saline in a 1:10 with water in adults and 0.9% saline to fluids in children. |
| Swallow metrics | The outputs of HRPIM which describe specific components of swallow physiology, including pharyngeal contractility, peak pressure, upper oesophageal relaxation and extent of opening. |

| | |
|---|---|
| Swallow selection | The process of choosing which swallows to analyse using analysis software. |
| Landmark placement | The first part of swallow analysis during which markers are placed on the topography plot to indicate regions of interest, including the onset and offset of upper oesophageal relaxation, the velo-pharynx and hypopharynx. |

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