The unrealised potential of videofluoromanometry (VFM) in dysphagia work-up

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Abstract. The unrealised potential of videofluoromanometry (VFM) in dysphagia work-up. Objective: To compare the actual and potential use of Videofluoromanometry (VFM) in dysphagia work-up.
Methodology: Qualitative paper based on (1) a review of literature in English and (2) experience-based opinion.
Results: The history, rationale and technical aspects of VFM are described. VFM indications are reviewed. The present clinical use of VFM is compared to the clinical potential originally foreseen.
Discussion: Several suggestions for achieving the unrealised potential of VFM are proposed based on personal experience with VFM.
Conclusion: Later studies should focus on relative pressure values rather than absolute values. A relative physiological variable is proposed: the Pharyngo-Oesophageal Pressure Gradient (POPG). A family of diseases with specific “manometric signatures” should be determined and a POG reading scale should be established accordingly. Once that has been done, subsequent studies should determine the best technical approach to recording the POG. Eventually, POG results should be compared to Modified Barium Swallow results in order to specify potential disease-specific VFM patterns.

Introduction

Videofluoromanometry (VFM), sometimes referred to as manofluorography or videomanometry in the literature in English, combines simultaneous computer pharyngo-oesophageal manometry and video-fluoroscopy. The aim is to study pharyngeal pressure generation and Upper Oesophageal Sphincter (UOS) relaxation in relation to bolus motion from the oropharynx towards the cervical oesophagus.

VFM offers quantitative information, by contrast with instrumental dysphagia work-up examinations such as Modified Barium Swallow (MBS) or Fiberoptic Endoscopic Evaluation of Swallowing (FEES®). These last two examinations, which are widely recognised as the gold standard examinations in the dysphagia work-up arsenal, remain qualitative examinations exposed to reliability issues.

The use of VFM remains limited, despite the quantitative data this instrumental examination is able to provide.

The purpose of this paper is to determine why this is so, and which barriers need to be overcome to allow VFM to reach its full clinical potential.

Literature review

VFM consists of the simultaneous recording of radiographic images and manometric data. The reasons why pioneers combined these two techniques are quite evident. Manometry alone in the pharyngo-oesophageal (PO) segment is difficult to interpret without concurrent X-ray. Likewise, the idea that it could be interesting to investigate PO pressure is associated with the definition of swallowing itself: swallowing is about pushing a bolus from the oral cavity towards the oesophagus while avoiding the false route. If the definition uses the word “push”, it implies the presence of a generated pressure, which is presumably somehow recordable.

Another reason why PO manometry still attracts interest is, by contrast with FEES® and MBS, its ability to provide quantitative data which allow for the calculation of p-values... As we know, physicians, and researchers even more, do like p-values!

History of VFM

The era of enthusiasms

It is still unclear who the first person was to combine videofluoroscopy and oesophageal manometry, even after careful reading of the literature in English. Sokol et al. were probably the first to provide a formal description of the technique in 1966. However, there is little doubt about the team who really
put the VF M on the “radar-screen”: Fred McConnel’s team.

In the late eighties, McConnel et al.9-16 wrote a series of articles on the VF M. The preliminary articles were rather qualitative, describing a biomechanical model of swallowing later referred to as “McConnel’s piston model”.

According to this model, “the oropharynx generates a propulsive pressure while simultaneously the UOS a negative pressure for the establishment of a bolus gradient creating a two-pump system”. Further citing McConnel: “Mano-fluorography (another word for VF M) allows analysis of the generation of the pharyngeal pressure gradient”.

In McConnel’s view, simultaneous videofluoroscopy allows one to determine the sources of the manometric waves and to relate timing to bolus passage appropriately. His enthusiasm was tempered by some counterintuitive and erratic results for absolute manometric measures within the PO segment before and after crico-pharyngeal myotomy.17 The main caveat of these articles is that PO manometry results always had to be interpreted and balanced with fluorovideography information. This explains why papers of this era generated more insights with their qualitative, rather than their quantitative, data.

Qualitatively, normal swallowing is described as two sequential positive manometric waves respectively measured at the oropharyngeal (T wave) and hypopharyngeal (C wave) levels. Simultaneous with the C wave, a negative manometric wave (E wave) is recorded at the level of the cricopharyngeal muscle (or upper oesophageal sphincter (UOS)). This general appearance is common to every pharyngo-oesophageal manometry, whatever the technology used and whatever the absolute values are (Figure 1). This is why McConnel is still considered the “father” of VF M, and his qualitative description of PO manometry remains largely valid today.18

Figure 1
Normal VF M showing T, C and E waves

Table 1

<table>
<thead>
<tr>
<th>Chronology</th>
<th>Pressure/Type</th>
<th>Name</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>1</td>
<td>Increased/Propulsion</td>
<td>T wave =</td>
<td>Produced by the tongue base moving posteriorly.</td>
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<tr>
<td></td>
<td>Force</td>
<td>Tongue Pressure</td>
<td></td>
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<tr>
<td>2</td>
<td>Increased/Propulsion</td>
<td>C wave =</td>
<td>Produced by pharyngeal constrictors contraction that eliminates the bolus from the laryngeal introitus.</td>
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<tr>
<td></td>
<td>Force</td>
<td>Constrictor Contraction</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Decreased/Suction</td>
<td>E wave =</td>
<td>Produced by the laryngeal elevation pressure that is superimposed on the UOS resting pressure.</td>
</tr>
<tr>
<td></td>
<td>Force</td>
<td>Laryngeal Elevation</td>
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At present, authors attribute the positive waves (T and C) essentially to tongue pressure, with the pharyngeal walls acting as a dynamic chamber, and the negative wave (E) to synergetic UOS relaxation and laryngeal elevation, causing passive opening of the UOS. Table 1 summarises the various waves involved in three-probe pharyngo-oesophageal manometry.

The era of doubt

As McConnel acknowledged in 1994, there had been much controversy in the early 1990s about the proper approach to the assessment of pressure changes within the PO segment. Indeed, (a) the asymmetry of UOS, making pressure measurements unpredictable, (b) the technical characteristics of manometric probes which need to provide a better reflection of the actual forces in the PO segment, (c) concerns about the axial
movement of the UOS, (d) the speed of movements during the pharyngeal phase of swallowing, (e) the probable existence of an age and gender influence on normative data, (f) the real nature of pressures that are measured within the PO segment (contact pressure, intrabolus pressure, a mix of both?), were only a few items on a large list that instilled doubt in the pioneers’ minds. In order to overcome these obstacles, their reactions were twofold:

(1) A focus on technical aspects by answering the following question: could we improve the recording technique and establish catheter standards in order to improve the reliability of measures, and consequently their physiological validity?

(2) A focus on clinical aspects by assessing the clinical utility of VFM despite its flaws.

This was an age of endless (and largely ongoing) discussions about the right resting pressure within the oesophagus, a time of sensors modifications and computerised analysis, continuous improvement initiatives and an age in which there were numerous methodology proposals for VFM.18-27

Meanwhile, papers written by prestigious authors were published advocating the clinical usefulness of VFM. Their main argument was the generation of data – whatever their physiological validity may have been – that augments information obtained from a barium swallow alone.26-37

Table 2 summarises the VFM indications based on an in-depth review of the topic in literature in English. Most of these indications match those proposed by Hila and Castell in 2001.38

<table>
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<th>Neuro-muscular diseases</th>
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<tr>
<td>Other congenital myopathies</td>
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<tr>
<td>Other acquired myopathies</td>
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</tbody>
</table>

| Parkinson’s disease and multiple system atrophy |
| Inflammatory and/or systemic disease |
| Dermatopolymyositis |
| Myositis |
| Scleroderma |
| Others |

| Drug-related dysphagia |
| Complex cases accumulating various diseases that potentially cause dysphagia |
| Suspicion of UOS motility dysfunction (with the exception of Zenker diverticulum) |

| Preoperative counselling before cricopharyngeal myotomy |

Discussion

The twofold trend in publications referred to above (with the emphasis on technical or clinical aspects) about VFM continues today. Nonetheless, the rather modest spread of VFM provides proof (if needed) that VFM has not reached its full potential, mainly due to the lack of universally approved standardisation and normative data.

Access to the technology may also represent a barrier. As a matter of fact, one can easily understand that costly investments are difficult to justify to administrators without clear standardisation and normative data, which are essential preconditions for proper costing and reimbursement.

Peter J Kahrilas stated, in an editorial published in a 1998 issue of “Dysphagia”, that several questions needed to be answered to assess the “value added” that VFM could provide within the context of dysphagia work-up.39 To paraphrase Kharilas et al.,39 two conditions have to be sequentially met in order to affirm the usefulness of VFM as a clinical test:

1. Families of disease conditions must exist with similar video-fluoroscopic abnormalities (or no abnormalities), but distinct manometric signatures.

2. A standardised VFM methodology must be feasible to distinguish properly between these possibilities.

In other words, VFM must first be examined from the vantage point of what physiologic variables need to be measured, and secondly, of how they may be detected.

This consideration is of key importance. To escape from this endless discussion about which technique and which methodology should supersede the other, we should rather be focusing our attention on (1) which physiologic variable would best reflect the physiopathology at issue and

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(2) which families of disease, with a specific manometric signature, would best benefit from VFMs.

Based on our personal experience of more than three hundred VFMs, and on a recently conducted prospective study which is presently under editorial review, we propose two answers to the above questions:

✓ Physiological variable: the Pharyngo-Oesophageal Pressure Gradient (POPG)

As mentioned before, absolute manometric values are difficult to obtain in an asymmetric lumen exposed to an environment that continuously changes during swallowing. Moreover, even if those intra-luminal absolute pressures were easy to record, the question of their nature (intra-bolus pressure, contact pressure, a mix of both) would remain open. One way to circumvent this difficulty is to adopt a relative value instead of an absolute value. By choosing the POPG, we are focusing on a “figure” obtained by the subtraction of two manometric values recorded by two sensors that are only one or two centimetres apart and exposed to a similar, yet different, environment at a specific moment.

The physiological meaning of this “figure” matters less than its correlation with dysphagic conditions, which are themselves presumably related to physiopathological features.

Our dysphagia team at St Luc’s Hospital uses a material and a methodology that conforms with the recommendations of Salassa et al.40 The distal sensor is placed at the level of the cricoid cartilage and posteriorly oriented. The POPG is determined, once the manometric waveform is recorded, by subtracting the UOS manometric value from the hypopharyngeal manometric value, at the precise moment when the hypopharyngeal sensor reaches its peak intensity during the first effective bolus swallow visible at the MBS.

✓ Indications (families of disease): the POPG reading scale

After the completion of a prospective study comparing the POPG of myotonic dystrophy patients (presenting a lack of propulsion forces) with the POPG of cricopharyngeal bar patients (presenting a high flow resistance force with appropriate propulsion response), and comparing these results with a non-dysphagic control group, we were able to propose a POPG reading scale that allowed us to further detect and categorise pathological conditions (Exhibit 1).

Dysphagia is far from being an on-off bimodal type symptom. As a matter of fact, there is a continuum comprising slight, moderate and severe dysphagia. Likewise, our results allow us to propose a concept of an aetiological continuum comprising (1) pharyngeal propulsion impairment characterised by low POPG values (below 100 mmHg), (2) normal or balanced pharyngeal propulsion characterised by moderate POPG values (between 100 and 200 mmHg) and eventually (3) excess of pharyngeal propulsion in reaction to an increased resistance to bolus flow characterised by high POPG values (above 200 mmHg).

Patients with POPG values to the left of the scale present a high probability of propulsion impairment while patients to the right of the scale present a high probability of increased resistance to bolus flow with an appropriate propulsive response. Patients with mixed aetiologies will present POPG results similar to healthy subjects.

It is important to note that the position on this scale does not reflect, by any means, the severity of the disease characterised by the penetration-
Unrealised potential of videofluoromanometry (VFM) as aspiration scale and/or the deficit of oral feeding capacities leading to nutritional deficiency. Likewise, VFM will not replace FEES® and MBS for the detection of dysphagia or for assessing its severity. FEES® and MBS are much more efficient and give better results. What it does offer though, particularly when interpreted with the reading scale presented here, is the possibility of important insights into the aetiology and the physiopathology related to the symptoms.

Practical examples of POPG reading scale utilisation

According to the literature, complex patients with numerous potential causes of dysphagia in their medical history will

Figure 2
VFM of Type 1 Arnold Chiari Syndrome with a POPG of 79 mmHg (83 – 4), and moderate residue in the valleculae at MBS

Figure 3
VFM of a patient with a mega-oesophagus (arrow) associated with a myastenia gravis before treatment. POPG of 6 mmHg, (4 – (-2)).
benefit from VFM in addition to FEES® and/or MBS. The technique gives the physician important insights into the swallowing physiopathology of those challenging cases. For example, Figure 2 shows the case of a patient presenting a slight dysphagia characterised by a moderate residue in the valleculae at MBS. The presence of a POPG below 100 mmHg triggered the realisation of a brain MRI indicating the presence of a Type 1 Arnold Chiari Syndrome.

Additionally, in our experience, VFM is of particular importance for patients suffering from neuromuscular diseases at an early stage when MBS, FEES®, physical examination and medical records fail to provide enough arguments to send the patient to the neurologist for further evaluation. VFM can obviously help the physician to guide the work-up effort appropriately.

Figure 3 shows the VFM of a patient in an aphagic condition referred to our institution. The patient could be fed only through a percutaneous endoscopic gastrostomy (PEG). The provisional diagnosis for this aphagia was mega-oesophagus. Intrigued by the sudden onset of dysphagia in a patient with a long-standing history of mega-oesophagus, we performed a VFM that showed a complete collapse of the POPG. This observation led us to request an electromyography (EMG) that confirmed the presence of a myasthenia. Figure 4 shows the results of the tensilon treatment of the same patient, indicating a dramatic rise of POPG values above 200 mmHg. The upward shift in POPG value in this patient therefore makes sense as an expected propulsion reaction to the high UOS resistance caused by the mega-oesophagus. Eventually, the patient regained oral feeding and the PEG was removed accordingly.
Unrealised potential of videofluoromanometry (VFM) is also very helpful in patients with dysphagia-aphagia in the context of a systemic disease (dermatomyositis, mitochondrial myositis, scleroderma etc…). VFM helps to stage the importance of pharyngeal propulsion impairment, and also to monitor progress during therapy. Figures 5 and 6 show the VFM results obtained for a patient with dermatomyositis before and after appropriate treatment. Both radiological and manometric results were spectacular.

In our experience, many cases of mild to moderate dysphagia that are not elucidated by the classical physical examination, FEES® or MBS work-up may benefit from VFM. Figure 7 shows the case of a patient suffering from myotonic dystrophy (Steinert’s disease) with no penetration aspiration and only a slight hypopharyngeal residue of contrast after swallowing, but already with a considerably lowered POPG of 48 mmHg.

Patients presenting with drug-related pharyngeal dysphagia also represent a population who will benefit from VFM. In these particular cases, it allows physicians to quantify the benefits of drug severance or dose modification. Figure 8 shows the VFM of a patient intoxicated with clonazepam. Figure 9 shows the same patient 6 weeks after complete severance. It is worth pointing out that, although there is not a large change in the MBS, the POPG has increased from 46 mmHg to 125 mmHg.

Finally, many authors have pointed out the benefits of performing a VFM before considering a cricopharyngeal myotomy. It is very useful in preoperative patient counselling because it assesses the remaining pharyngeal propulsion capacity of the patient. Figures 10 and 11 show the VFMs of two patients referred to our institution for cricopharyngeal myotomy. The patient in figure 10 shows some propulsion impairment with a...
radiological Rosenbek Class 4 penetration-aspiration and a POPG of 91 mmHg and some ramping curves. By contrast, the patient in figure 11 has perfect pharyngeal propulsion with a normal MBS and a POPG of 210 mmHg. The results of the cricopharyngeal myotomy were indeed less satisfactory in the patient in figure 10 than for the patient in figure 11.

The benefit of pre-op counselling before cricopharyngeal myotomy was underlined in a recent paper from Brigand et al. showing that myogenic dysphagia constitutes the biggest risk factor for such procedures. Further study will be necessary to demonstrate whether the lack of appropriate propulsion to overcome the increased resistance to flow of the UOS is a result of propulsion fatigue or an independent condition.

**Conclusion**

Dysphagia specialists in general, whether SLPs or physicians, deplore the failure to use pharyngeal manometry in dysphagia work-up. They are convinced of the potential of pharyngeal manometry in general, and of VFM in particular, but do not see any clear way to exploit it clinically on a large scale. As pointed out above, access to the technology, a lack of measurement standards, and a lack of technical standardisation are major contributors to this paradox.

In order to overcome this paradox, a relative physiological variable is proposed: the Pharyngo-Oesophageal Pressure Gradient (POPG). A family of diseases with specific “POPG signatures” should be determined and validated by further studies. Likewise, the POPG reading scale should be established and tested accordingly. Once this has been done, later studies should determine the best technical approach to recording the POPG. Eventually, POPG

**Figure 8**

VFM of a clonazepam-intoxicated patient with a low POPG value of 46 mmHg (44 – (-2)) and slight MBS abnormalities.

**Figure 9**

VFM of Figure 9 patient 6 weeks after drug severance, showing a restored POPG value of 125 mmHg (129 – 4).
Unrealised potential of videofluoromanometry (VFM)

results should be compared to Modified Barium Swallow results in order to specify potential disease-specific VFM patterns.

References


Figure 10

VFM of a patient eligible for cricopharyngeal myotomy with a low POPG of 91 mmHg (120 – 29) and a Rosenbec class 4 penetration at MBS.

Figure 11

VFM of a patient eligible for cricopharyngeal myotomy with a high POPG of 210 mmHg (219 – 9) and no post-swallow pharyngeal residue at MBS.

G. Desuter et al.