AGA Technical Review on the Clinical Use of Esophageal Manometry

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The utility of esophageal manometry in clinical practice resides in 3 domains: (1) to accurately define esophageal motor function, (2) to define abnormal motor function, and (3) to delineate a treatment plan based on motor abnormalities. Since the first American Gastroenterological Association technical review on esophageal manometry published 10 years ago,[1,2] advances have been made within each of these domains. By and large, these advances have not been the result of major technological changes but rather a reflection of improved manometric technique and research. With this in mind, the goal of this second technical review on the clinical use of esophageal manometry is to summarize what has been learned during the past 10 years and discuss how this has modified the clinical management of esophageal disorders. Thus, we performed a literature search for all English-language articles dealing with manometric evaluation of the esophagus from 1994 to 2003. The databases searched included MEDLINE, PreMEDLINE, and PubMed using general terms related to manometric technique (sleeve, topography) and equipment (water perfused, solid state), esophageal symptoms (dysphagia, chest pain, heartburn), esophageal disorders and procedures (gastroesophageal reflux disease, achalasia, diffuse esophageal spasm, nutcracker esophagus, hypertensive LES, nonspecific motor disorders, ineffective esophageal motility, fundoplication, myotomy, dilation), and terms focused on esophageal motor function (upper esophageal sphincter, lower esophageal sphincter, esophageal body, peristalsis). Additional references were identified from references of reviewed manuscripts.

1994–2003: How Has Esophageal Manometry Changed?

Manometry is by nature a highly technical evaluation, more akin to physiologic studies than to endoscopic or radiographic ones. When optimally utilized and providing that physical principles and equipment characteristics are respected, a manometric examination provides an accurate description of esophageal contractile function. In general, manometric data are only as valid as the methodology used to acquire them.

The frequency content of esophageal contractile waves defines the required characteristics of a manometric recording device. The frequency response required to reproduce esophageal pressure waves with 98% accuracy is 0–4 Hz, while that required for reproducing pharyngeal pressure waves is 0–56 Hz.[3] Expressed in terms of maximal recordable $\Delta P/\Delta t$, 300 mm Hg/s will suffice for the mid or distal esophagus versus 4000 mm Hg/s for the pharynx. Because the overall characteristics of the manometric system are only as good as those of the weakest element within that system, high-fidelity recordings require that each element (pressure sensor, transducer, recorder) meet or exceed these response characteristics. Modern computer polygraphs and pressure transducers, essentially unchanged in the past 10 years, have response characteristics greatly exceeding those required for esophageal manometry. Thus, most of the methodological evolution that has occurred during the past 10 years has been in the domains of manometric assembly design and data analysis; each of these will be reviewed.

Manometric Assemblies

The pressure sensor/transducer components of a manometric assembly function as a matched pair and are available in 2 general designs: water-perfused catheters with volume displacement transducers or strain gauge transducers with solid-state circuitry. Major advantages of water-perfused systems are cost and versatility. A major disadvantage is that the equipment is fickle and proper maintenance requires skilled personnel. Illustrative of the versatility possible with perfused manometric assemblies, the past 10 years have witnessed the introduction of multilumen, autoclavable, miniature silicone

Abbreviations used in this paper: DES, diffuse esophageal spasm; EGJ, esophagogastric junction; GERD, gastroesophageal reflux disease; IEM, ineffective esophageal motility; tLESR, transient lower esophageal sphincter relaxation; UES, upper esophageal sphincter.

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extrusions that can be configured with nearly infinite variety.

Faithful recording of sphincter pressure for extended periods of time or during swallow-related esophageal shortening requires that the pressure sensor maintain a constant position within the high-pressure zone. Sleeve sensors were devised to meet these requirements. However, sleeve sensors were originally made of molded silicone and, before 1994, manometric extrusions were made of polyvinyl chloride. Thus, the sleeve sensor needed to be joined to the end of the polyvinyl extrusion with a complex joint involving metal stents and suture. Although functional, the resultant assembly probably would not meet current requirements for reuse mandated by the need for restoring sterility. On the other hand, the multilumen silicone extrusions currently available (Mui Scientific, Mississauga, Canada; formerly Dentsleeve) can incorporate sleeve sensors directly onto the extrusion, making the resultant assembly both more durable and autoclavable. These catheters have undergone rigorous reuse evaluation and have been deemed safe for reuse by both the Food and Drug Administration (via the 510k mechanism) and EU regulators (CE marked and monitored).

An alternative to perfused manometric systems is a manometric assembly incorporating miniature strain gauge sensors and solid-state electronic components. The microtransducers directly interface with the recorder, and the resultant system has a vastly expanded frequency response suitable for pharyngeal recording. On the negative side, solid-state systems are much more expensive, are less modifiable, are more delicate, and do not yet have the versatility of assembly design permissive of either a sleeve sensor or topographic data presentation (see following text). Improvements in design are currently under way, and it is likely that high-resolution solid-state systems will be available in the near future. One other appeal of solid-state systems is that they are not subject to hydrostatic effects and can be miniaturized, factors that make them more suitable for extended ambulatory studies. Having said that, recent research has shown successful use of a portable water-perfusion pump with a sleeve assembly and the resultant publications have provided substantial insight into the pathogenesis of reflux[4] and the mechanisms of reflux in patients with and without a hiatus hernia.[5]

Manometric Data Analysis

Given that most manometric recording systems are computer based, the potential exists for automated analysis. Automated analysis of manometric tracings is an appealing concept because it could lead to standardization of what has otherwise been a highly operator-dependent evaluation. However, the pitfalls of interpreting esophageal manometric tracings are plentiful. For example, pressure thresholds established to distinguish contractions from miscellaneous artifacts may ignore hypotensive peristaltic contractions below that threshold. Similarly, the ability of automated analysis to accurately characterize the adequacy of lower esophageal sphincter (LES) relaxation or to differentiate isobaric common cavities from spastic contractions has not been adequately validated. These subtle distinctions can be absolutely crucial in establishing an accurate diagnosis. Thus, although currently available programs may be useful adjuncts in the interpretation of (normal) manometric recordings, automated analysis has not yet matured to a degree that it can replace manual inspection by an experienced clinician. Guidelines for performance of esophageal manometry and standardized reporting are crucial to decrease the degree of subjective interpretation between clinicians. Although not covered in this review, detailed methods regarding these issues were recently published by members of the American Motility Society and the European Society of Neurogastroenterology and Motility Working Group on Esophageal Manometry.[6]

An offshoot of the introduction of multilumen miniature extrusions has been the application of topographic data presentation to manometric recordings. Topographic analysis is a method of axial data interpolation derived from computerized plotting of data from multiple, closely spaced recording sites.[7] The interpolated pressure information is plotted as either a 3-dimensional surface plot or a 2-dimensional contour plot in which pressure amplitude is represented by concentric rings or color gradients with an appropriate scale (Figure 1). The advantage of this presentation is that it provides a complete, dynamic representation of peristalsis at every axial position along the esophagus, as opposed to the fragmented data presented in conventional manometric tracings. However, even though this technique has provided significant insight into the physiology of peristalsis and has the potential to redefine the way we evaluate sphincter relaxation, it is debatable as to whether or not it has yet demonstrated any clear advantage over conventional manometry in clinical practice.[8]

Intraluminal Impedance Monitoring

Although manometric apparatus has not changed significantly in the past 10 years, there has been significant interest in combining manometry with a newly evolving technology, intraluminal impedance monitoring. Impedance monitoring works by quantifying the impedance between pairs of metal