Principles of MII Testing

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Multichannel intraluminal impedance (MII) is a relative new technique first developed a little over a decade ago at the Helmholz Institute in Aachen, Germany. Silny, et al (1) first described this technique as a new method of assessing intraluminal bolus movement based on differences in conductivity to alternating current of intraluminal content.

The basic component of this method is the impedance circuit (Figure 1). Two metal (steel) rings separated by an isolator are connected to an alternating current (AC) generator. In order for the circuit to be closed electric charges between the two metal rings have to travel in the area surrounding the isolator. When surrounded by air there is almost no current flow between the two rings and therefore the impedance (i.e. resistance to alternating current) measured between the electrodes is very high. When placed within the esophagus current flow between the two metal rings is enabled by electric charges within the esophageal mucosal, submucosal and muscular layers. Any other material present within the esophagus will produce characteristic changes due to [1] the electric conductivity (directly related with ionic concentration) and [2] the cross section (i.e. the lower the cross-section the higher the impedance). The electrical impedance, being the opposite of conductivity, decreases from air, to mucosal lining, to saliva/swallowed material to refluxed gastric contents (lowest impedance) as shown in Figure 2.

The appearance of a liquid bolus between the two impedance rings produces the following changes (2) (Figure 3a): [1] a drop in impedance when the current flow is enabled by the liquid part of the bolus followed by [2] a rise in impedance as the bolus is cleared from this segment by a peristaltic wave; [3] an "overshoot" in impedance corresponding to decreased luminal cross-section during muscle contraction and [4] return to baseline. Current conventions consider the bolus entry point at the 50% drop from baseline to nadir and bolus exit at the recovery of impedance to this 50% value (2).

The appearance of an air bolus (i.e. belch, air swallow) will produce very rapid rise in impedance to high values (usually greater than 5000 Ohms) followed by the same rapid decrease in impedance once the air bolus clears from this segment (Figure 3b).

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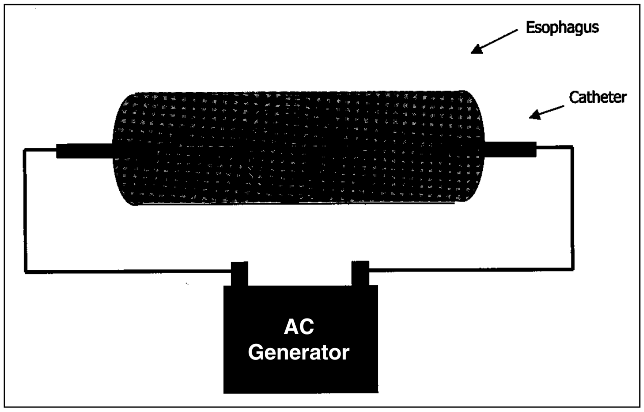

Figure 1. Schematic representation of the intraesophageal impedance circuit. Two metal rings on a catheter are attached to an AC generator. The electric circuit is closed by the electric charges (ions) within the lumen between the two metal rings.

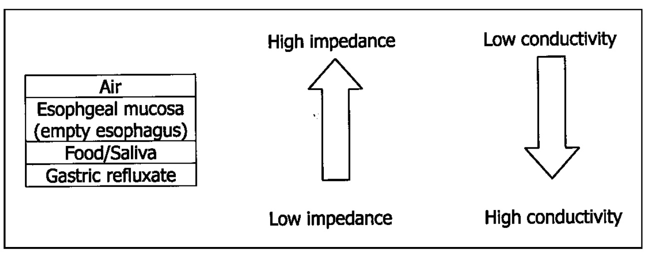

Figure 2. Intraesophageal constituents arranged according to their relative impedance and conductivity.

The appearance of a mixed (liquid and gas) bolus between the two rings produces the following changes (Figure 3c): [1] a rise in impedance produced by the presence of air in the front of the bolus; [2] rapid drop in impedance when the current flow is enabled by the liquid part of the bolus followed by [3] a rise in impedance as the bolus is being cleared from this segment; [4] an "overshoot" in impedance corresponding to decreased luminal cross-section during contraction and [5] return to baseline.

The use of serial impedance measuring sites on a single catheter or multichannel intraluminal impedance (MII) allows determination of the direction of bolus movement within the esophagus. Progression of imped-

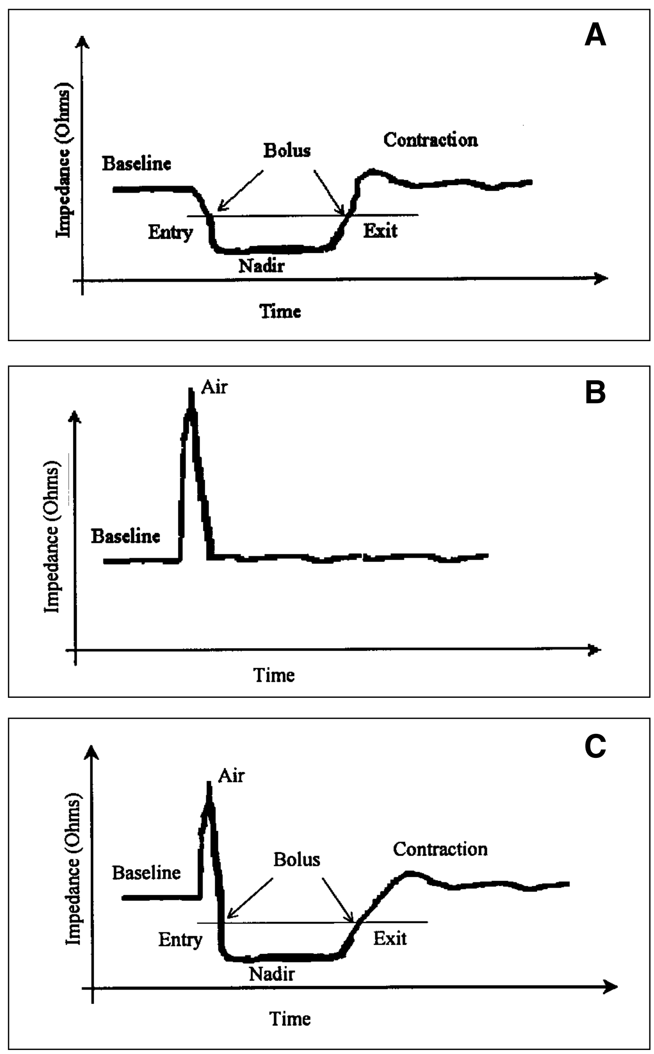

Figure 3. Impedance changes observed during bolus transit over a single pair of measurement rings separated by 2 cm. (a) Liquid boluses will produce a drop in impedance once the liquid part of the bolus reaches the impedance measuring site persisting as long as the bolus is present in this segment. Lumen narrowing produced by the contraction transiently increases the impedance above baseline. (b) Air (gas) presence in the impedance measuring segments will produce a sharp and transient rise in impedance (usually over 5000 Ohm) due to poor electric conductivity of air. (c) Mixed (air-liquid) boluses will produce a rapid rise in resistance, noted when air traveling in front of the bolus head reaches the impedance measuring segment followed by a drop in impedance once higher conductive bolus material passes the measuring site. Bolus entry is considered at the 50% drop in impedance from baseline relative to nadir and bolus exit at the 50% recovery point from nadir to baseline. Lumen narrowing produced by the contraction transiently increases the impedance above baseline.

ance changes from proximal to distal are indicative of antegrade bolus movement as observed during swallowing (Figure 4a). Progression of impedance changes from distal to proximal are indicative for retrograde bolus movement as observed in reflux (Figure 4b).

Combining MII with esophageal manometry (MII-EM) or pH (MII-pH) expands the armamentarium of diagnostic tools to evaluate esophageal function in patients with esophageal disorders.

Combined MII-EM allows simultaneous measurement of intraesophageal pressures and bolus movement (3,4). Since this technique is not using radiation or radionuclide labeled material to evaluate intraesophageal bolus transit there is no limit on the number of swallows that can be analyzed. Since both MII rings and pressure sensors are mounted on the same catheter without a change in size of the catheter, this test is not different from regular manometry from the patient's perspective. Nor does combined testing change the test sequence.

Combined MII-pH represents a shift in the reflux-testing paradigm (5,6,7). Gastroesophageal reflux is no longer primarily detected by pH but the presence of gastroesophageal refluxate of all types within the esophagus is detected by MII. It can detect bolus volume presence independent of the chemical (i.e. pH) composition of the refluxate. In combined MII-pH the pH sensor is used simply to characterize whether the refluxate is acid or non-acid based on pre-defined criteria. Similar to combined MII-EM, addition of impedance rings to a pH catheter does not change its size or the performance of ambulatory monitoring.

Augmenting either esophageal manometry or ambulatory pH monitoring with the addition of MII has provided important new information in patient evaluation that will be discussed in the next two articles in this series. The MII technology should not be considered as a replacement for current manometry and pH techniques, but rather a complementary procedure that expands the diagnostic potential of esophageal function testing without use of radiation. ■

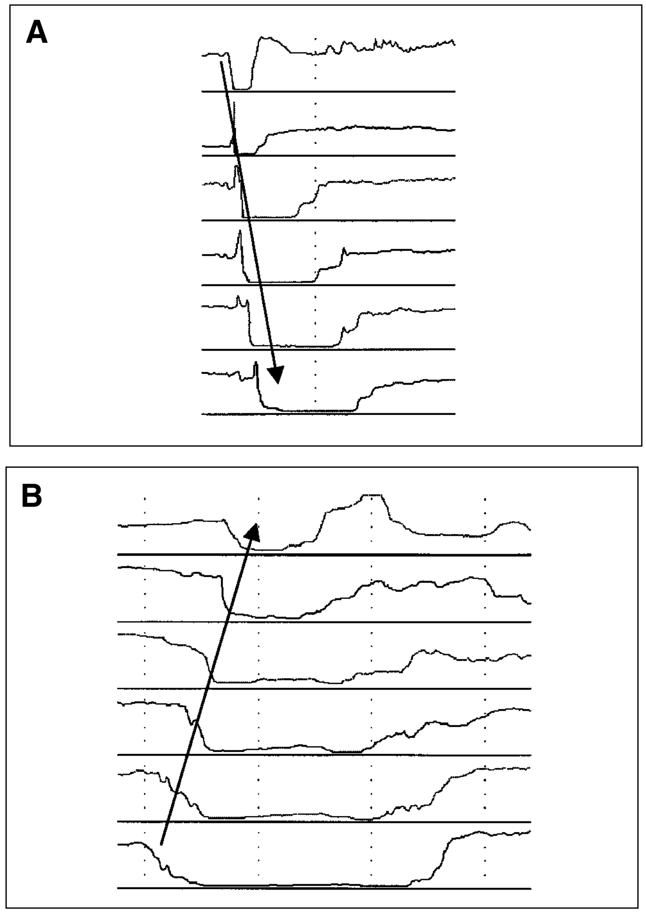

Figure 4. Using multiple impedance measuring sites MII can detect direction of bolus movement. Progression of impedance changes from proximal to distal (a) are indicative of antegrade bolus movement as observed during swallowing while progression of impedance changes from distal to proximal (b) are indicative for retrograde bolus movement as observed in reflux.

References

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