Electrogastrography: Methodology, Validation and Applications

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Electrogastrography (EGG) is a non-invasive method for the measurement of gastric myoelectrical activity. It was first discovered in 1921 and popularized in 1990s. EGG is attractive because it is non-invasive. However, due to its non-invasive nature, there have also been controversies regarding validity and applications of EGG. The aim of this review is to discuss the methodologies, validation and applications of EGG. Pros and cons of EGG will also be discussed in detail. First, the gastric slow wave and its correlation with gastric motility are presented. The association between gastric dysrhythmia and impaired gastric motility is reviewed. Secondly the method for recording the electrogastrogram is presented in detail and pitfalls in the recording and analysis of EGG are discussed. Thirdly, findings reported in the literature demonstrating the accuracy of EGG in recording gastric slow waves and gastric dysrhythmia are reviewed and discussed. The correlation of the electrogastrogram with gastric contraction is carefully discussed. Finally, applications of EGG in a few major areas are reviewed.

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Key Words
Electrogastrography; Gastric slow waves; Gastrointestinal motility

Introduction

Electrogastrography is a non-invasive technique for recording gastric myoelectrical activity using cutaneous electrodes placed on the abdominal skin over the stomach. The surface recording obtained using electrography is called the electrogastrogram. In this review, both electrogastrography and electrogastrogram are abbreviated to EGG: “EGG” refers to the electrogastrography (the technique of recording the electrogastrogram) and “the EGG” refers to the electrogastrogram (the recording).

The EGG was first introduced in 1922 by Alvarez,1 rediscovered by Davis et al2 in 1957 and popularized in 1990s.1 Due to its non-invasive nature, EGG has received substantial attention among researchers and clinicians and also the controversies and concerns arose. Some researchers use the EGG as a non-invasive measure of gastric slow waves and even consider it as a surrogate of gastric motility, whereas, others claim the EGG is flawed or even merely an artifact of gastric motions. In this article we will review available information in the literature and try to give readers an objective assessment of this non-invasive technique in detecting gastric slow waves.
To judge whether EGG is useful as a research and/or clinical tool, one needs to first understand completely what can be measured by EGG and how the EGG should be recorded and interpreted. Although it was unclear before 1960s whether the EGG was a recording of gastric myoelectrical activity or contractile activity, it is now clear that the EGG is a measurement of gastric slow waves. We will first review electrophysiology of the stomach, that is, gastric myoelectrical activity that can be measured using internal electrodes implanted on gastric serosa.

Secondly, we will provide technical details on how to measure the EGG. Since the EGG is a non-invasive measure using abdominal skin electrodes, it is sensitive to motion artifacts and electrical interferences from other internal organs. Therefore, it is critically important to measure the EGG appropriately and accurately. Detailed information will be provided on how to prepare the abdominal skin, where to place electrodes, how to choose filtering range (extremely important) and how to avoid and minimize motion artifacts.

Recently, some researchers have suggested that the EGG or any extracellular recordings of the stomach might be a mere measure of stomach movement artifact or contractile artifact. To answer this question, we will review numerous findings published in the literature as well as from our own labs regarding the validity of EGG. Data will be reviewed in 3 categories: (1) the relationship between the internal extracellular myoelectrical recording and gastric contractions: this will tell whether the internal extracellular myoelectrical recording is a measurement of true gastric myoelectrical activity or just an artifact of gastric contractions, (2) the relationship between the EGG and the internal serosal recording of the gastric slow wave: this will determine whether the EGG is an accurate measurement of gastric slow waves, and (3) the relationship between the EGG and gastric contractions. We believe that by reviewing these materials, the reader will be capable of determining whether the EGG is a measurement of gastric slow waves or just gastric contractile artifacts.

Last but not least, we will review applications of EGG, including the application of EGG for the study of gastric electrophysiology, the use of EGG in assessing the effect of an intervention and the clinical relevance of EGG in patients with symptoms suggestive of functional gastric dysmotility.

Gastric Myoelectrical Activity

Normal Gastric Myoelectrical Activity

Like in the heart, there is myoelectrical activity along the gut. Myoelectrical activity of the stomach consists of slow waves and spike potentials. The slow wave is also called pacesetter potential, or electrical control activity, whereas, spike potentials are referred to as action potentials or electrical response activity. The frequency of normal gastric slow waves is species-dependent, being approximately 3 cycles per minute (cpm) in humans and 5 cpm in dogs. The gastric slow wave determines the maximum frequency and propagation of gastric contractions. Figure 1A presents normal gastric slow waves measured from a dog using internal electrodes permanently implanted on gastric serosa. Distally-propagated slow waves at a frequency of about 5 cpm are clearly noted.

Spike potentials are considered as electrical counterparts of gastric contractions, i.e., a gastric contraction occurs when the slow wave is accompanied with spike potentials. We would like to point out, however, in the most part of the stomach, especially in the fundus and proximal antrum, a one-to-one correlation between spike potentials and gastric contractions is not commonly seen. It is not uncommon to record gastric contractions at the absence of spike potentials in the stomach.

Gastric Dysrhythmia and Abnormal Slow Waves

Gastric myoelectrical activity may be altered or become abnormal in diseased states or upon provocative stimulations or even spontaneously. Abnormal gastric myoelectrical activity includes gastric dysrhythmia, abnormal slow wave propagation and electro-mechanical uncoupling. Gastric dysrhythmias can be further classified into bradygastria, tachygastria and arrhythmia. From internal serosal recordings, we know that the normal frequency of the gastric slow wave in humans is about 2-4 cpm, whereas bradygastria is in the range of 0.5-2.0 cpm and tachygastria in the range of 4-9 cpm. Tachygastria is usually ectopic and of an antral origin as shown in our lab. In more than 80% of cases, it is located in the antrum and propagates retrogradely. It may override completely the normal distally-propagated slow waves. However, in most cases, it does not completely override the normal gastric slow waves. In these cases, there are 2 pacemaking activities: a normal pacemaker in the proximal stomach and a tachygastrial pacemaker in