JPMA (Journal Of Pakistan Medical Association) Vol 53, No.9,Sep. 2003
Original Articles

Normal Oesophageal Manometric Values in Healthy Adult Volunteers

W. U. Ahmed, E. A. Vohra
Department of Medicine, Ziauddin Medical University Hospital, Karachi.

Introduction

Oesophageal manometry is a relatively simple technique for the diagnosis of oesophageal motility disorders. It started way back in 1883 when Kronecher and Meltzer used air-filled baloons for oesophageal manometry which was connected to a manometer1, later water filled balloons used by Ingelfinger and Abbott2 in 1940. Winans and Harris introduced perfused tubes in 1967.3 Finally Arndorfer introduced capillary infusion system in 1977.4

With the introduction of this technique many oesophageal motor abnormalities have been detected and treated. Use of computer in this field has revolutionized the diagnostic accuracy and reproducibility of the results. It has also made the procedure user friendly especially in terms of calculating results.
Before introducing the manometrics studies in a country, normal pressure variations in controls should be determined. The present study was done to achieve this objective.

Subjects and Methods

Oesophageal manometry was done in 25 healthy volunteers. All the cases with upper gastrointestinal symptoms, metabolic diseases, respiratory and cardiac diseases and those taking any medicine for upper G.I. symptoms or who had GI surgery were excluded. All the steps of the procedures were explained in detail and a verbal informed consent was taken prior to the procedure. The anxiety of the subjects was minimized by discussing and explaining the procedure to them.

Equipment

An eight lumen water perfused polyvinylchloride catheter was used. The diameter of the catheter was 4 mm, containing 8 capillary lumens within the catheter of approximately 0.8 mm in diameter and has side openings 0.8 mm in diameter around a central lumen. Each of the eight capillary tubes has an opening at a set point along its length. The eight orifices are numbered 1 through 8, with number 1 being the most distal and number 8 the most proximal. The four distal orifices, number 1 through 4 are 1 cm apart and oriented radially at 90 degree angles. These orifices are used primarily for lower oesophageal sphincter (LOS) determination. The four proximal orifices, numbers 5 through 8, are 5 cms apart and are also oriented at 90 degree angles. These are used for assessment of pressures in the body of the oesophagus.

The other end of the catheter consists of eight individual capillary tubes. Each capillary tube is marked for identification and ending with a special tip for connection to the external transducers, set on a rack at the same level as the subject's oesophagus in the supine position and are connected to both the hydraulic infusion pump and polygraph. The infusion pump perfuses the catheter at a constant rate and pressure. When the individual catheter orifices are occluded (either by a contracting LOS or a wave in the oesophageal body), the pressure in the water filled tube rises and this is recorded by the external transducers. This pressure information is subsequently converted to an electrical signal by the transducer and displayed on a dedicated computer monitor.

Procedure

Calibration of the transducers was done before starting the procedure with a manometer having a mercury column. Manometer was attached directly to an external transducer with a three-way stopcock. Using an air filled syringe varying amounts of pressure was applied to the transducers and matching was done between the pressure shown on the manometer and the pressure displayed on the computer monitor.

Subjects were asked to come for the procedure after an over night fast to reduce the risk of aspiration during intubation. Detail history was taken about any medication taken 48 hours prior to the test, to exclude any possible influence of medication (prokinetic drugs, nitrates, anticholinergics, Calcium channel antagonists or sedatives) on the oesophageal motility.

Subjects were asked to remove any dentures (if any) if they felt more comfortable without them. The catheter lumens were prefilled with sterile water and the lumens were capped to retain the fluid, which also helped to prevent saliva and food debris from filling the lumens. The first few centimeters of the catheter was immersed in water to reduce friction during intubation and no local anaesthetic was used while passing the manometry catheter.

The subject was seated during intubation and the catheter was passed horizontally through the nares into the oro-pharynx across the upper region of the hard palate. When the catheter entered the pharynx, the subject was asked to tilt the head forward towards the chest and swallow. In difficult cases, sips of water using a straw was allowed to facilitate the entry of the catheter through the pharynx and upper oesophageal sphincter.

The catheter was inserted sufficiently, so that there were no pressure measuring ports covering at least 10 cm of the stomach i.e when the 50 cm mark on the tube was at the tip of the nose. Once the catheter was in position the subject was asked to lie supine with a pillow under the head and a straight head. The catheter was connected to the transducers and infusion commenced. A period of at least 10 minutes were allowed for stabilization of the subject's state and the recording system. The subject was asked to limit their swallowing as the pharyngeal irritation caused by the catheter is accentuated by repeated swallowing. The catheter tips 1 through 4 were connected to the transducers and the water at the infusion pump was turned on with a transfusion rate of 0.6 ml / minute.

The subject's name, age, sex, hospital number and the date were entered in the computer. Before starting the procedure it was verified that all perfused ports or transducers are in the stomach by recognizing a relatively flat smooth tracing with a small pressure increase moving upwards on inspiration. This confirmed the placement in the stomach and is referred to as the gastric baseline. The subject was asked to take a deep breath with the operator watching the tracing. If the tracing went down with inspiration, the ports are confirmed to be in the oesophagus and not in the stomach. If portions of the tracing went up while others go down, or if all go up but are not smooth and flat, the catheter is then partially in the sphincter and the tube is passed further down.

The Lower Oesophageal Sphincter

Lower oesophageal sphincter functions were measured by station pull through technique (SPT). With this technique, the catheter is moved through the LOS one centimeter at a time, with a pause at each point, or station, to closely observe LOS pressure and relaxation. The subject was asked to relax and concentrate on breathing regularly and evenly and they were asked to swallow as little as possible.

Pulling out of the tube started at a speed of 1 mm/sec and the location of the tube was recorded. The tube was moved out 1 cm and the distance was recorded, the tracing was examined simultaneously. If the tracing remained unchanged, the tube was moved another centimeter, and this was continued till an increase in pressure was noted on the tracing, which corresponded with the breathing. This exaggerated respiratory response is seen while the port is in the LOS because of the close proximity of the sphincter to the diaphragm. The catheter was moved 1 cm at a time and at least 3 to 5 respiratory cycles were recorded at each station. As the catheter was moved further, the bottom of the pressure complex was raised above the gastric baseline. At this point, an assessment of sphincter relaxation was made by asking the subject to swallow; and a drop in pressure to about the level of the gastric baseline being observed. If the relaxation did not appear complete (did not go down to gastric baseline) a 5 ml swallow of water was given to achieve a complete relaxation up to the gastric baseline pressure. Following a swallow during the SPT, more than 8 seconds were spent at each station to allow the effects of the swallow to clear.

The catheter is then withdrawn at 1 cm intervals, till a point when the tracing goes down rather than up with inspiration, this is identified as the "respiratory inversion point", where the port moves from the abdominal cavity into the thoracic cavity. When the most distal port enters the body of the esophagus, baseline pressures were noted and the catheter was adjusted to 3 cm above the point and the tube was taped in place. The connections were changed from port 1, 2, 3, 4 to ports 1, 5, 6, 7 to take the readings of the body of the oesophagus.

The Body of the Oesophagus

For this portion of the study, the perfused ports or transducers were kept 5 cm apart, with the most distal being 3 cm above the LOS, so that the ports 5, 6 and 7 remain at 8, 13 and 18 cm above the LOS respectively. Subjects were told that they shall be given a teaspoon full of water to swallow which they would hold at the back of their throat and swallow as a single bolus. They were explained that swallows will be given every 30 seconds and they will have to swallow as explained. Recording was started at a speed of 2.5 mm/sec. Initially the subject was asked to perform a dry swallow; tracings were observed and the pressure range was adjusted accordingly. If the subject did not swallow spontaneously after 30 seconds, another dry swallow was asked, similarly 10 dry swallows recorded. Later using a syringe and water at room temperature, 5 ml bolus of water was instilled in the patient's mouth and swallowed as a bolus. If the subject did not swallow spontaneously after 30 seconds, another 5 ml water bolus was given. Ten such wet swallows were recorded.

Upper Oesophageal Sphincter (UOS)

UOS was studied by station pull-through, method. Speed was increased to 5 mm/sec and the range of the distal transducer to around 100 mm Hg. Catheter was pulled out slowly while watching the proximal baseline. When a rise in pressure was observed, withdrawal was stopped and tracing was watched for few seconds, then recorded for 15-20 seconds before measuring the pressure and moving the catheter to the next station. After measuring the resting UOS pressure, relaxation of the sphincter was recorded by asking the subject to swallow.
Once the tube was completely withdrawn from the subject, it was disconnected from the infusion pump. Water was injected through the individual capillary tubes and the catheter was rinsed. Final washing of both the inside and outside of the catheter was done with a mild germicidal solution, followed by a thorough rinsing and drying to make the tube ready for the next study.

Seven out of 25 healthy controls had double peaked peristaltic contractions, which is quite common and variant of the normal oesophageal peristaltic contraction.8

Data Analysis

All tracings were analyzed and pressure readings recorded. Sphincter pressure was reported as the difference from gastric pressure. First the maximum respiratory oscillation of the sphincteric pressure above the expiratory gastric baseline was measured which is called peak sphincteric pressure. Mean pressure of each respiratory oscillation was calculated and the maximum height of this mean pressure above the expiratory gastric baseline was defined as the mean sphincteric pressure. Similarly the peristaltic amplitude of the oesophageal body was measured from the oesophageal base line pressure. Mean was calculated from the individual peristaltic amplitude. Duration was calculated from the onset to the end of peristaltic amplitude. Progression of the waves was calculated using the computer after the marking of commencement and end of the peristaltic waves.

Results

Oesophageal manometric studies were done in 25 healthy controls.There were 19 males and 6 females whose ages ranged from 14 to 67 years with a mean age of 41 + 16 years. Height of the subjects ranged from 124.5 to 179 cms, and weight ranged from 38 to 82 kg.

Lower end of the oesophagus was noted at 45.98 + 2.9 cms. Respiratory inversion point was at 43.85 + 3.1 cms. Upper end of the lower oesophageal sphincter was at 42.77 + 3.2 cms.

Resting pressure of the lower oesophageal sphincter ranged from 3.14 to 37.65 mm Hg. Mean relaxation of the lower oesophageal sphincter was 96 + 4.1 %. Data regarding lower oesophageal sphincter is given in Table 1.

Peristaltic amplitude of the oesophageal body was highest at the lower end of the oesophagus both for dry and wet swallows mean values being 56.23 + 27.9 mm Hg and 74.28 + 35.8 mm Hg respectively. Distal oesophageal amplitude was 54.18 + 18.6 and 70.91 + 24.3 mm Hg for dry and wet swallows respectively. Readings of the peristaltic amplitude at different levels are given in Table 2.

Duration of the peristalsis was lowest at the upper end of the oesophagus both for dry and wet swallows being 3.48 + 0.88 and 3.5 + 1.3 seconds respectively. Highest duration of peristaltic amplitude was noted at the lower end of the oesophagus being 4.43 seconds both for dry and wet swallows. Distal oesophageal peristaltic duration was 4.28 + 0.7 and 4.43 + 0.8 seconds for dry and wet swallows respectively. Duration of peristaltic amplitude at different levels is given in Table 3.

Progression of the peristaltic waves at the proximal end was 3.41 + 1.8 cm / sec and 2.64 + 1.3 cm / sec for dry and wet swallows respectively and at the distal end it was 3.87 + 1.4 and 3.37 + 1.6 cm / sec for dry and wet swallows respectively.
Mean resting pressure of the upper oesophageal sphincter was 49.84 + 22.4 mm Hg. Mean residual pressure was 5.2 + 9.3 mm Hg. Duration of relaxation was 1.35 sec. Details of the upper oesophageal sphincter is given in Table 4.

Discussion

Present study was an effort to establish the base line data for oesophageal manometry in healthy controls. We have used station pull-through technique for the measurement of lower esophageal sphincter pressures. The advantage of this method is that it is more accurate then rapid pull-through measurements and it can also measure the relaxation of the sphincter in response to a swallow.5,6 In this study end-expiratory pressure at the lower oesophageal sphincter was taken as the lower oesophageal sphincter pressure, as in one study it was suggested that end-expiratory pressure are more indicative of the true resting lower oesophageal sphincter pressure, as at this point in the respiratory cycle the diaphragmatic contribution to the observed pressure is minimum.7 Mean resting pressure of the lower oesophageal sphincter in our series was 13.43 + 7.1 mmHg in the end-expiratory phase of breathing, which is almost similar to the other reported series8 of healthy adult volunteers, i.e. 15.2 + 10.7 mm Hg. The mean age of that control series was 43 years which is closer to this series being 45 years. Other parameters of lower oesophageal sphincter like end-inspiratory pressure of 40.95 + 20.1 mm Hg and mid-expiratory pressure was 27.31 + 13.23 mm Hg , which is also similar being 39.7 + 23.2 mm Hg and 24.4 + 10.1 mm Hg respectively.

Mean relaxation of the lower oesophageal sphincter was 96 % . Duration of relaxation was not calculated as later studies have shown that the residual pressure, which is defined as the difference between the lowest pressure achieved during relaxation and the gastric baseline pressure, is a better indicator of the function then percentage of relaxation, since this parameter is independent of the resting lower oesophageal sphincter baseline pressure. In this study mean residual pressure was 0.74 + 1.2 mm Hg.

Measurements of the amplitude, duration and progression of the waves are usually measured from peristaltic contraction following wet swallows.5 An average of five wet swallows were calculated for this purpose, as in one study the reproducibility of swallow parameters were evaluated for 5 to 8 swallows, which was found reliably characteristic of an individual's oesophageal peristalsis.9 Amplitude of the peristaltic contraction was quite low i.e DEA 54.18 + 18 mm Hg in this series as compared to 99 + 40 mm Hg reported in one series5 but it is similar to other series.10 This difference could be due to the difference in the average built of the population which is quite low in our series. Duration of contraction of and progression of the waves are comparable to the reported series.

Seven out of 25 healthy controls had double peaked peristaltic contractions, which is quite common and variant of the normal oesophageal peristaltic contraction.8

References

1. Kronecher H, Meltzer S. Der schuluckmechanismus, seine Erregung und seine Hemmung. Arch Anat Physiol 1883;7:328-62.

2. Ingelfinger FJ, Abbott WO. Intubation studies of the human small intestine: diagnostic significance of motor disturbances. Am J Dig Dis 1940;7:468-74.

3. Winans CS, Harris LD. Quantitation of lower oesophageal sphincter competence. Gastroenterology 1967;52:773-8.

4. Arndorfer RC, Stef JJ, Dodds WJ, et al. Improved infusion system for intraluminal manometry. Gastroenterology 1977; 73:23-7.

5. Castell DO, Castell JA. Esophageal motility testing, 2nd ed. Norwalk: Appleton

and Lange. 1994, pp. 61- 91.

6. Humphries TJ, Castell DO. Pressure profile of esophageal peristalsis in normal humans as measured by direct intraesophageal transducers. Am J Dig Dis 1977;22:641- 5.

7. Boyle JT, Altschuler SM, Nixon TE, et al. Role of the diaphragm in the genesis of lower esophageal sphincter pressure in the cat. Gastroenterology 1985;88:723-30.

8. Richter JE, Wu WC, Johns DN, et al. Esophageal manometry in 95 healthy adult volunteers. Dig Dis Sci 1987;32:583-92.

9. De Vault K, Castell JA, Castell DO. How many swallows are required to establish reliable esophageal peristaltic parameters in normal subjects? An on-line computer analysis. Am J Gastroentrol. 1987;82:754-7.

10. Welsh RW, Drake ST. Normal lower esophageal sphincter:; a comparison of rapid vs slow pull through techniques. Gastroenterology 1980 78:1446-51.