

# Standard Oesophageal Manometry in Healthy Adults in Singapore

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## Abstract

*Data on oesophageal manometry in normal subjects in the East are limited. The aim of this study was to define standard oesophageal pressure values in a group of healthy adults in Singapore. Standard oesophageal manometry was performed on 26 asymptomatic volunteers (12 males and 14 females, aged 19 to 34 years) using the water-perfused capillary system and stationary pull-through technique. Median (range) lower oesophageal sphincter pressure, distal oesophageal contractile amplitude, distal oesophageal contractile duration and distal oesophageal contractile velocity were 13.6 (8.0 to 32.0) mmHg, 93.0 (41.0 to 143.0) mmHg, 3.8 (3.2 to 5.3) s and 3.6 (2.2 to 4.6) cm/s respectively. They were similar in males and females except for distal oesophageal contractile velocity which was higher in males than females [4.0 (3.1 to 4.6) cm/s versus 3.2 (2.2 to 4.4) cm/s,  $P < 0.01$ ]. They were also generally in line with published normal values from Western countries. The present study helps to establish standards for normal manometric findings, at least among the young adults, in this part of the world.*

*Ann Acad Med Singapore 1999; 28:189-92*

**Key words:** Diffuse oesophageal spasm, Lower oesophageal sphincter, Oesophageal contraction, Oesophageal motility, Oesophageal peristalsis

## Introduction

Although standard oesophageal manometry has been widely used in the West for many years, normal manometric values that have been well described for healthy volunteers in the West may not be applicable to this part of the world. Such normal values vary between investigators, even within the same study population. The discrepancy is due to many factors, including differences in instruments used, techniques of data acquisition as well as methods of analysis. It is therefore recommended that every motility laboratory should have its own database to define normal oesophageal pressure values.<sup>1</sup> We therefore perform standard oesophageal motility in a group of healthy individuals in Singapore.

## Materials and Methods

The study group comprised of 26 ambulatory paid volunteers recruited from student residence halls at the National University of Singapore. Sixteen of these volunteers also took part in a study on the manometric effect of chilli. Results of their manometric findings during the control phase, as previously described,<sup>2</sup> were included as normal manometric findings in the present study. Each volunteer was interviewed and when ap-

propriate, underwent physical examination to ensure they had no obvious medical illnesses. Volunteers were excluded if there was any history of symptoms referable to the upper gastrointestinal tract. Additionally, no volunteer had a history of upper abdominal surgery such as cholecystectomy, gastric resection, or selective proximal vagotomy, diabetes mellitus, alcoholism, collagen vascular disease, or neurological disorders. Written informed consent was obtained from the participants and the study was approved by the Ethics Committee of the National University Hospital, Singapore.

## Oesophageal Manometry

Oesophageal manometry was performed, as previously described,<sup>2</sup> using a quadruple-lumen polyvinyl catheter (inside diameter of each lumen, 0.8 mm; outside diameter of catheter, 3.2 mm) with radially orientated side ports spaced 5 cm apart (Mui Scientific, Ontario, Canada). The lumens were perfused with distilled water at a rate of 0.6 ml/min from a low-compliance pneumohydraulic capillary infusion system (model PIP-4, Mui Scientific, Ontario, Canada). The catheter was connected to an external pressure transducer with output on a physiograph recorder (model 8805c, Hewlett Packard Medical Electronics, Andover, MA,

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USA). Data were recorded at a paper speed of 1 mm/s for pressure measurements from the lower oesophageal sphincter and 2.5 mm/s for those from the oesophageal body.

Patients were evaluated in the fasting state and in a supine position. All medications known to affect oesophageal contractions and pain perception were withheld for at least 72 hours before the study. The catheter was passed through the nostril into the stomach and left in-situ for a 5-min acclimation period. It was then withdrawn slowly in 0.5 cm increments and held at each station for 60 seconds using a standard stationary pull-through technique. The basal lower oesophageal sphincter (LOS) pressure was estimated from the maximal end-expiratory pressure difference with respect to the gastric baseline. It was calculated as the average of four pressure readings obtained from the four recording sites during the stationary pull-through manoeuvres. LOS relaxation was determined from the maximal decrease to gastric baseline of the end-expiratory sphincteric pressure during wet-swallows. The percent relaxation was calculated as a percent of the full drop from the LOS pressure to the gastric baseline. The distances from the external nares to the lower and upper borders of the LOS were determined for all subjects. The length of sphincter was defined as the distance between these two manometric landmarks. The four catheter openings were next positioned in the oesophageal body at 3, 8, 13, and 18 cm above the LOS. Oesophageal contractions were recorded from these openings in response to fifteen consecutive 5-ml swallows of water at room temperature given at 30 seconds intervals. The first five swallows were used as a training period to adapt the volunteers to the technique and therefore only the last 10 swallows were analysed. Wave amplitude and duration was obtained by measuring, respectively, the height from the mean oesophageal baseline to the peak and the width from the extrapolated onset of the rapid upstroke to the return to baseline. These were determined individually for the recording sites 3, 8, 13 and 18 cm above the LOS. The individual values for the recording sites 3 and 8 cm above the LOS were also combined and designated as distal oesophageal contractile amplitude (DOA) and distal oesophageal contractile duration (DOD) respectively. These latter pressure measurements are particularly important as recent evidence suggests that most oesophageal abnormalities are confined to this region of the oesophagus.<sup>3</sup> Velocity was determined by dividing the time between the onset of the major upstroke of the waves at the 13-cm and 3-cm recording sites into the 10 cm distance between ports. Contraction waves were evaluated for the presence of double-peaked, triple-peaked or repetitive contractions at all recorded levels of the oesophageal body. The presence of peristaltic, simultaneous, non-conducted, or retrograde contraction se-

quences was determined by examining the coordination between the contractions on each recording site. For individual subjects, the measurement of each these contraction parameters represented the mean of ten sequential wet swallows. The number of spontaneous oesophageal contractions during a subsequent 5-min quiet period was also recorded. During the period, the subjects were instructed to relax, not to talk and swallow. All tracings were read blindly without knowledge of age and gender of the subject.

#### *Definitions of Contraction Parameters*

A measurable contraction wave was defined as a rise in amplitude above the baseline of at least 10 mmHg; the threshold was chosen to avoid the potential artefact of respiratory variation. Double-peaked contractions were contractions with a second peak of at least 10 mmHg in amplitude occurring at least 1 second apart from the initial contractions. If a third peak that fulfilled the above two criteria was also present, the contraction was said to be triple-peaked. Repetitive waves were defined as contractions which occurred in quick succession of each other with the amplitudes crossing the threshold level i.e. 10 mmHg several times within a short period. Peristalsis was considered to be present if contractions occurred in successive channels, one after the other, separated by a time interval of at least 0.5 seconds (wave onset to wave onset). This minimal time interval between recording sites was chosen to permit clear discrimination by visual reading of peristaltic from simultaneous contractions. The latter contractions were those which occurred at the same time in different recording sites. Motor activity that was absent or less than 10 mmHg in amplitude at a given site was nominated non-conducted wave. Isolated (segmental) contractions represented those which occurred in one channel but not in the others, i.e. contraction amplitude >10 mmHg in one channel and <10 mmHg in the other channels. Spontaneous contractions were defined as spontaneously occurring contractions, greater than 10 mmHg, that were not generated by dry swallows during the quiet period.

#### *Statistical Analysis*

All manometric results were given as median (range) unless otherwise stated, as a preliminary assessment showed them to assume a non-parametric distribution. The upper and lower reference limits were established as the 95th and 5th percentiles respectively of all manometric variables. Comparison of data was performed using the Kruskal Wallis test. Probability values were two-tailed and those <0.05 were regarded as significant. All statistics were performed using the Statistical Package for the Social Sciences for Windows (SPSS, Chicago, IL, USA).

## Results

### Demography

Of the 26 healthy volunteers studied, 12 were males and 14 were females. Their median (range) age was 23 (19 to 34) years. Twenty-two were Chinese, 2 were Indians and 2 were categorised Others. All were non-smokers except for 3, of whom only 1 was a current smoker. None consumed excessive alcohol.

### Manometric Data

#### (1) Position and length of LOS

The median (range) distance of the upper border of the LOS from the nares was 41.3 (36.0 to 49.0) cm. The corresponding figures for the length of the LOS were 4.5 (2.8 to 6.0) cm. Males had a significantly longer LOS to nares distance than females [median (range), 43.3 (41.5 to 49.0) cm versus 38.8 (36.0 to 42.0) cm,  $P < 0.0001$ ]. There was however no difference in length of the LOS between the two genders [median (range), males 4.0 (3.0 to 6.0) cm versus females 4.8 (2.8 to 5.5) cm].

The median, range, 5th and 95th percentiles values for the various parameters of LOS and contraction waves are shown in Tables I and II, respectively.

TABLE I: LOWER OESOPHAGEAL SPHINCTER DATA FOR 26 HEALTHY VOLUNTEERS

|                                             | Median (range)  | 5%-95% percentiles |
|---------------------------------------------|-----------------|--------------------|
| Lower oesophageal sphincter pressure (mmHg) | 13.6 (8.0-32.0) | 8.2-32.0           |
| Lower oesophageal sphincter relaxation (%)  | 96.5 (80-100)   | 80-100             |

TABLE II: PRESSURE DATA FROM OESOPHAGEAL BODY FOR 26 HEALTHY VOLUNTEERS

|                        | Median (range)     | 5%-95% percentiles |
|------------------------|--------------------|--------------------|
| Amplitude (mmHg)       |                    |                    |
| - 18 cm                | 48.0 (13.0-122.0)  | 15.5-106.6         |
| - 13 cm                | 54.5 (24.0-108.0)  | 29.6-105.6         |
| - 8 cm                 | 79.5 (37.0-137.0)  | 38.1-133.9         |
| - 3 cm                 | 105.5 (43.0-166.0) | 43.7-159.7         |
| - 3/8 (DOA)            | 93.0 (41.0-143.0)  | 41.4-142.0         |
| Duration (s)           |                    |                    |
| - 18 cm                | 3.5 (2.8-5.0)      | 2.8-4.9            |
| - 13 cm                | 3.8 (2.8-7.2)      | 2.9-6.5            |
| - 8 cm                 | 3.7 (2.9-5.4)      | 3.0-5.1            |
| - 3 cm                 | 3.8 (3.0-5.2)      | 3.0-5.1            |
| - 3/8 (DOD)            | 3.8 (3.2-5.3)      | 3.2-5.0            |
| Distal velocity (cm/s) | 3.6 (2.2-4.6)      | 2.2-4.5            |

DOA: distal oesophageal amplitude; DOD: distal oesophageal duration

#### (2) LOS pressure and relaxation

Median (range) LOS pressure was 13.6 (8.0 to 32.0) mmHg whilst the median (range) LOS relaxation was 97% (80% to 100%). Gender had no effect on both the LOS pressure and LOS relaxation.

#### (3) Amplitude

Median (range) distal oesophageal contractile amplitude (DOA) was 93.0 (41.0 to 143.0) mmHg. Amplitude increased distally along the oesophagus. Mean contractile amplitudes were similar in male and female subjects.

#### (4) Duration

Median (range) distal oesophageal contractile duration (DOD) was 3.8 (3.2 to 5.3) s. Median (range) contractile durations were similar in male and female subjects except for those at the 18-cm recording site which were greater among males than females [4.0 (3.0 to 5.0) s versus 3.5 (2.8 to 4.30) s,  $P < 0.05$ ].

#### (5) Velocity

The distal oesophageal contractile velocity ranged from 2.2 to 4.6 (median 3.6) cm/s and was higher in males than females [4.0 (3.1 to 4.6) cm/s versus 3.2 (2.2 to 4.4) cm/s,  $P < 0.01$ ].

### "Abnormal" Motor Responses

#### (1) Multi-peaked waves

Double-peaked waves were relatively common. They were present at least once in 42% (11/26) of the individuals. Among them, double-peaked waves occurred in 8, 2 and 1 subjects during 10%, 20% and 30% respectively of the wet swallows. Triple-peaked wave was present once in only 1 of our subjects.

#### (2) Non-peristaltic contractions

None of our subjects were observed to have simultaneous, non-conducted, isolated or retrograde contractions during the series of 10 wet swallows.

#### (3) Spontaneous contractions

During the 5-min quiet period, all subjects were observed to have spontaneous oesophageal activity not associated with dry swallows. These contractions were usually of low amplitude (median 20 mmHg, range 10 to 90 mmHg). Forty-two per cent of these contractions were simultaneous, and 11% were repetitive. The frequency of spontaneous contractions ranged from 3 to 35 (median 9) per 5-min period. Subjects were unaware of these spontaneous contractions.

## Discussion

As the field of oesophageal motility has moved from an art to a science, it is important to define the range of normal values. It is known that normal values vary between different laboratories due to factors such as

differences in the populations studied, instruments used, techniques of data acquisition as well as methods of analysis. Each laboratory therefore should establish its own population reference values and employ standardised laboratory methods that closely resemble those used in obtaining normal values. For this reason, we derived our own normal values from local asymptomatic volunteers and used these values for our subsequent patient studies.

The normal values for LOS pressure, contraction duration and velocity were generally in line with reports from other groups studying healthy persons.<sup>3,4</sup> Contraction amplitudes were however lower in the present study than that of Richter et al.<sup>3</sup> The younger age of our volunteers (19 to 34 years versus 22 to 79 years in their study) and to a lesser extent, the smaller catheter size (3.2 mm versus 4.5 mm in their study) probably account for the discrepancy. It has previously been shown that oesophageal contractile amplitude increases with age and catheter size.<sup>4</sup> We recognise our normal group was not ideal and should have included persons of older ages. We were unable to do so because of practical difficulty in recruiting older people as volunteers.

In the present study, the distance from the external nares to the upper oesophageal sphincter was not measured manometrically, and so the true oesophageal length (distance between the upper and lower oesophageal sphincters) could not be ascertained. Our normal values for the nostril-LOS distance are remarkably close to values obtained using endoscopic technique—the mean distances from the incisor teeth to the oesophagogastric junction were reported to be  $40.9 \pm 2.8$  cm and  $44.4 \pm 3.0$  cm ( $\pm$ SD) respectively in two studies amongst Asian populations.<sup>5,6</sup> Consistent with a previous manometric study,<sup>7</sup> males had a longer nostril-LOS distance, therefore longer oesophagus than females. The discrepancy probably reflects differences in stature between the two genders as a Chinese group of workers reported a fair correlation between manometrically measured oesophageal lengths and body heights of their subjects.<sup>8</sup> This could not be confirmed in the present study as heights were not measured.

In agreement with a previous study,<sup>4</sup> we found double-peaked waves to be common after wet swallows. The appearance of triple-peaked waves, however, was a rare finding. There was only one such wave in 1 subject out of the 26 normal volunteers (260 total wet swallows). These findings support previous conclusion<sup>3</sup> that triple-peaked contraction waves, but not double-peaked contraction waves, are suggestive of an oesophageal motility disorder. As has been previously documented: simultaneous contractions were not associated with wet swallows in any of our subjects. Hence, the definition of diffuse oesophageal spasm based on the presence of

greater than 10% simultaneous contractions after wet swallows interspersed with normal peristalsis is adequate in our local population.'

All our subjects experienced some spontaneous activity during a 5-min quiet period. This is not a new observation, as other studies had previously documented the spontaneous occurrence of simultaneous and repetitive contractions, resembling those of diffuse oesophageal spasm, during resting period.<sup>4,10</sup> Janssens et al<sup>10</sup> found such non-deglutitive activity in 24 of the 25 normal subjects. They suggested that the spontaneous activity probably represented the oesophageal component of phase 3 of the migrating motor complex and should not necessarily be considered a sign of disordered motility. One unexpected finding from the present study was the frequent and high number of spontaneous contractions observed in some of the subjects, which have not previously been reported.<sup>4,10</sup> The clinical significance of such a finding is undetermined.

In conclusion, our study should help to establish standards for normal manometric findings, at least among the young adults, in this part of the world.

### Acknowledgement

This work was supported by the Academic Research Grant RP3900364 from the National University of Singapore. The authors wish to thank Mr C O Ho for his technical assistance.

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