

Standard values for gas-perfusion manometry of the esophagus

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Abstract

The manometry with water-perfused or solid-state catheters is the predominant diagnostic procedure to detect motility disorders of the esophagus. Another method is the manometry using gas-perfused catheters. Although the high-resolution manometry is the method of first choice, the conventional manometry with helium has some advantages: the simple and hygienically unproblematic use and the absence of any artefacts by the perfusion medium compared with water-perfusion, and the considerably lower costs compared with the solid-state catheters. Every method has own normal values because of the specific pressure transmission and the design of the catheter probes. To our knowledge, normal values for gas-perfusion manometry of the esophagus have not yet been published.

The esophageal manometry with helium-perfused catheters was performed in 30 healthy volunteers. The main parameters of the esophageal motility and the lower esophageal sphincter were analyzed by liquid and bolus-like swallows and compared with the previous published values in other manometric procedures.

The values of the motility in the distal esophagus are consistent; the pressure of the lower esophageal sphincter is generally lower than with other methods. The distal wave amplitude and the propagation velocity are significant higher in the distal esophagus than in the middle. The perfusion medium is well tolerated by the investigated volunteers.

Abbreviations: BSW = bolus-like swallows, LES = lower esophageal sphincter, LSW = liquid swallows, MP = measuring point.

Keywords: esophageal motility, gas-perfused catheters, helium, manometry of the esophagus, normal values

1. Introduction

Depended on the kind of catheter 2 methods of esophageal manometry are commonly established: the water-perfusion and the solid-state manometry. The water-perfusion manometry is the older and cheaper diagnostic procedure to detect the changing of pressure inside of the esophagus, especially to assess the esophageal motility and the lower esophageal sphincter. This method entails some drawbacks: the mass and the kinetic energy of the flowing water, the water induced swallowing, and the expenditure to bleed and clean the measuring system. The use of electronic solid-state catheters is comparatively simple, and there are not hygienic problems. Due to the surface-mounted pressure transducers, the solid-state catheters are directly connected to the esophageal lumen and wall. It could not be found any artefacts and disturbances could not be found. The high number of measuring points is the

precondition to perform the high-resolution manometry. The criteria for diagnosis of esophageal motility disorders have been well-defined by the Chicago Classification.^[1,2] According to this classification, the diagnostic accuracy and reproducibility are significant higher than in conventional manometry with limited number of measuring channels.^[3] The most important disadvantage is the significantly higher cost; the measuring device and the catheters are very expensive.

A further method for performing esophageal manometry is the use of gas-perfused catheters. The suitability of the inert gas helium for measuring of pressure and pressure changings in muscular hollow organs was proved by the Austrian physicist Rehak in 1982.^[4,5] We use the gas-perfusion manometry for >25 years in the clinical practice.^[6–8] About 3500 examinations of the esophagus have been carried out. An available device for gas-perfusion manometry is the UMS 5e system by the German company Medizintechnik Wadewitz in Leipzig.

The coupling between the origin of pressure changing and the transducer respectively bioelectrical connection is depended on the physical method and the configuration of the measuring catheter. Every method has their own values, which can be compared one another only approximately.

To our knowledge, the standard values in healthy persons had not yet been published.

2. Material and methods

The study has been approved by the Ethics Committee of the Martin-Luther University Halle-Wittenberg.

Thirty young healthy volunteers, 14 men and 16 women, have been included. The mean age was 24.5 ± 2.24 years, the mean body mass index was 23.3 ± 3.06 , 24.8 ± 2.93 in men and 22.0 ± 2.56 in women. Most of them had 3 meals (range, 2–5) and 2 L of

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Table 1**Examination procedure with measuring time and helium volume (inflow 5 mL per minute and channel, 8 channels).**

Phase	Position	Medium and volume for swallowing acts	Time (min), mean/SD	Helium volume (mL), mean/SD
Positioning of measuring catheter	Upright			
Static measurement			3.7 ± 1.05	146 ± 42.2
	Transition		1.0 ± 0.00	40 ± 0.0
Swallowing acts	Supine	Liquid, 10 × 5 mL	8.6 ± 1.21	342 ± 48.3
		Bolus-like, 5 × 5 mL	6.9 ± 1.23	274 ± 49.0
	Transition		2.0 ± 0.00	80 ± 0.0
	Upright	Liquid, 10 × 5 mL	9.6 ± 2.27	383 ± 90.8
		Bolus-like, 5 × 5 mL	7.4 ± 1.24	295 ± 49.6
	Transition		3.0 ± 0.00	120 ± 0.0
Pull-through measurement	Upright		3.9 ± 1.09	155 ± 43.7

beverages (range, 1–3.5) per day, were non-smokers and consumed few or no alcohol. There were neither chronic diseases nor previous surgery, which could have a negative impact on the esophageal function. No one showed acute gastrointestinal symptoms.

The volunteers answered a questionnaire, before and after the test.

The manometric examination consisted of the following main steps: static measurement, liquid and bolus-like acts of swallowing in supine and upright position, and a profile measurement in pull-through technique (Table 1). The channels of the catheter with a diameter of 0.4 mm were perfused with 5 mL helium per minute. The measuring points were positioned as side holes spaced as follows: 1 in the stomach, 4 in the lower esophageal sphincter (LES) in 1 cm steps, and 3 in the esophageal body 5 cm above the LES in further steps of 6 cm, in summary 8 channels. The average position of the highest measuring point in the esophageal body was 26.5 ± 2.98 mm below the row of teeth depended on the esophagus length and the location of LES.

3. Results

3.1. Measurement procedure

The total measurement time was 46 ± 5.0 minutes, due to the transition phases the real measurement time was 40 ± 5.0 minutes. The inflow volume of helium during the whole time measurement was on average 1834 ± 200.3 mL, during the real measurement time 1594 ± 200.3 mL.

3.2. Motility

In the distal wave amplitude there was no difference between the supine and the upright position of the test persons and between the liquid and bolus-like swallows. However, a significant difference was between the amplitude at the highest measuring point and the both middle and lowest measuring points (17 vs 11 and 5 cm above LES) (Fig. 1A, B). The mean value of the distal wave amplitude in the distal esophagus (11 and 5 cm above LES) was 105 ± 29.2 mmHg.

There were no differences in the duration of swallowing contraction between the body position, the height of the measuring point, and the consistency of the swallowing bolus. It could be found only a slight tendency to increase of duration in the supine position from the middle to the distal esophagus (Fig. 2A, B). The mean value of the duration of swallowing contraction in the distal esophagus (11 and 5 cm above LES) was 3.4 ± 0.57 second.

The propagation velocity was significant higher from measuring point 2 to 3, resp. between 11 and 5 cm above LES, in supine

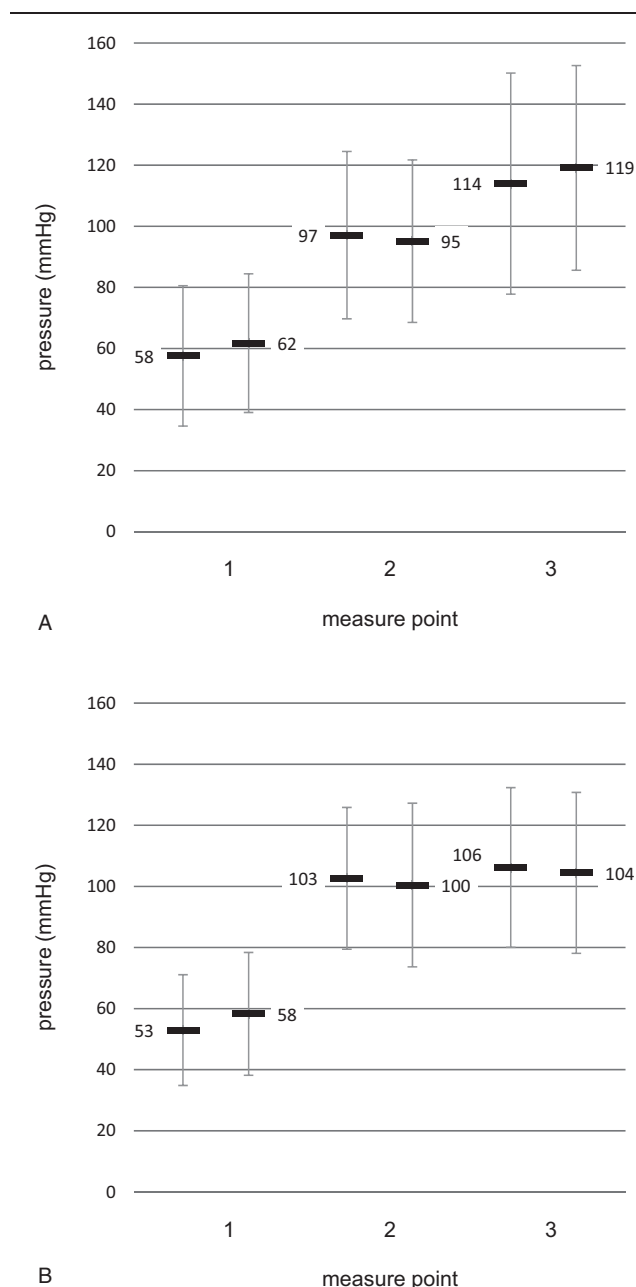


Figure 1. Amplitude in supine (A) and upright (B) position, LSW and BSW. Peak of pressure wave in LSW (left) and BSW (right) at each MP 1–3, MP 3 about 5 cm above LES, fixed distance between MP 1, 2, and 3 is 6 cm. BSW = bolus-like swallows, LES = lower esophageal sphincter, LSW = liquid swallows, MP = measuring point.

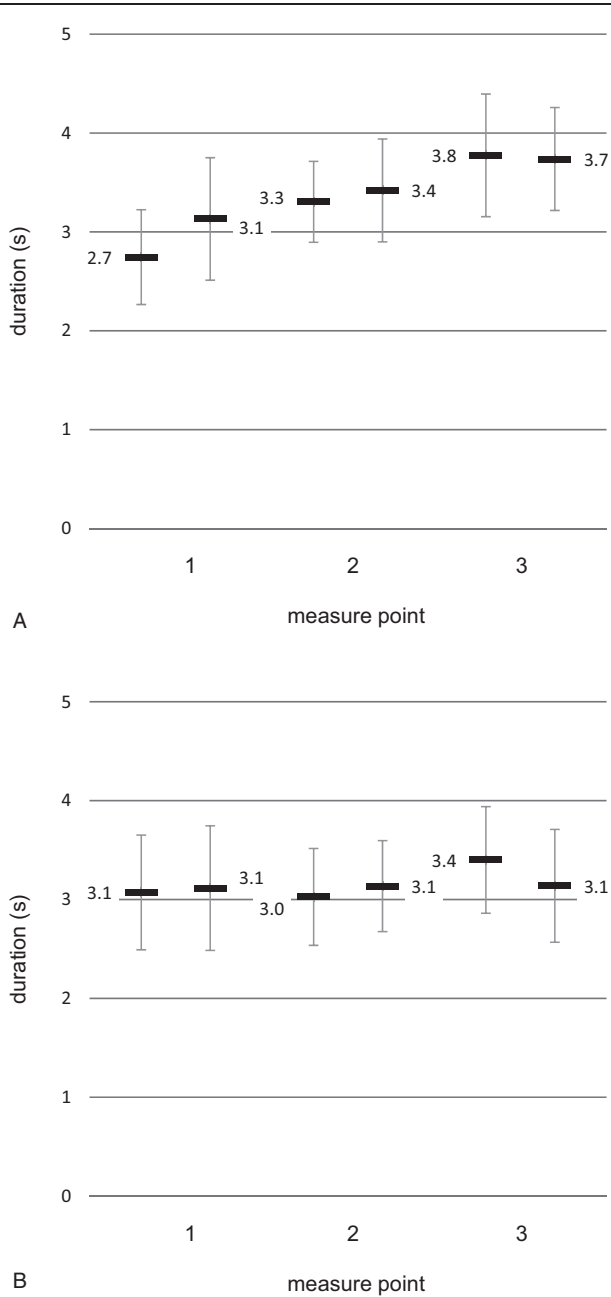


Figure 2. Duration in supine (A) and upright (B) position, LSW and BSW. Duration of esophageal contraction in LSW (left) and BSW (right) at each MP 1–3, MP 3 about 5 cm above LES, fixed distance between MP 1, 2, and 3 is 6 cm. BSW=bolus-like swallows, LES=lower esophageal sphincter, LSW=liquid swallows, MP=measuring point.

body position. In upright position there could be found only a slight tendency in this. There was no difference in the consistence of swallowing bolus. The mean value of the propagation velocity in the distal esophagus (from 11 to 5 cm above LES) was 4.1 ± 1.13 cm/s (Fig. 3A, B).

3.3. Lower esophageal sphincter

It could not found any differences in resting pressure (basal pressure), sphincter relaxation, and post relaxation pressure between supine and upright position, and between liquid and bolus-like swallows. The mean resting pressure, residual pressure

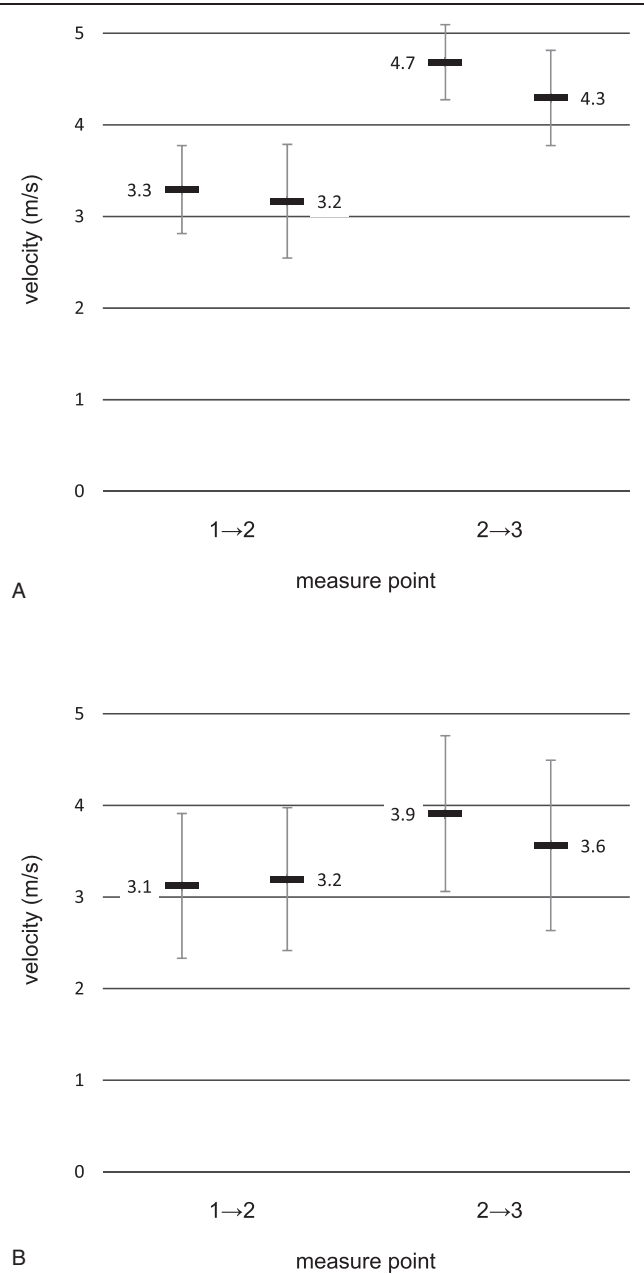


Figure 3. Propagation velocity in supine (A) and upright (B) position, LSW and BSW. Velocity of swallow wave between MP 1 and 2, and MP 2 and 3 in LSW (left) and BSW (right), MP 3 about 5 cm above LES, fixed distance between MP 1, 2, and 3 is 6 cm. BSW=bolus-like swallows, LES=lower esophageal sphincter, LSW=liquid swallows, MP=measuring point.

(minimal pressure during the relaxation), and post relaxation pressure (increase) were as follows: 13.6 ± 4.17 , 0.2 ± 0.54 , and 71.7 ± 22.42 mmHg (Fig. 4A, B).

3.4. Questionnaire

The questionnaire could be completely evaluated in 29 of 30 test persons. Fifty-ninepercent had feared that the examination could be unpleasant or painful, 48% have found it uncomfortable, but after the end of the test only 21% have been felt slightly affected. The supine position was more compromising in 41% versus upright position in 17% and without preference in 41%. A gag

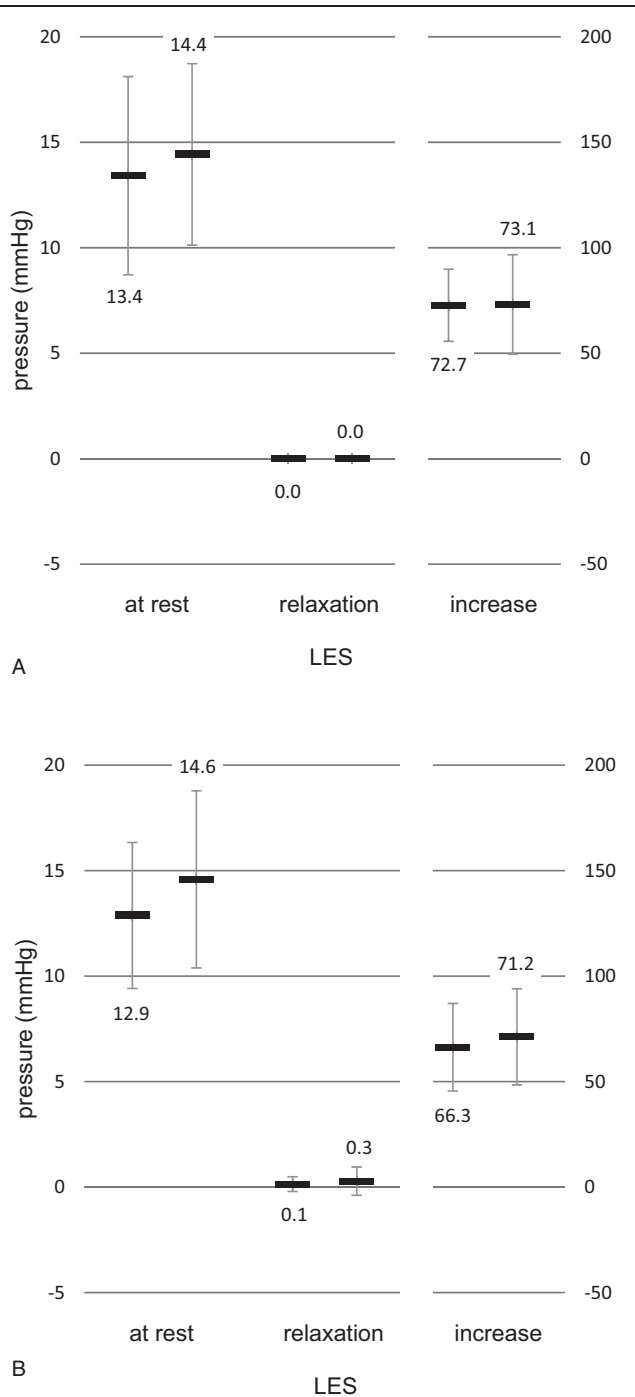


Figure 4. LES in supine (A) and upright (B) position, liquid and bolus-like swallows, resting pressure, relaxation, and post-relaxation pressure increase in LSW (left) and BSW (right). BSW = bolus-like swallows, LES = lower esophageal sphincter, LSW = liquid swallows.

reflex has been felt by 48%, particularly in the catheter positioning, a foreign body sensation by 97%, and a slight tickle of the throat only by 14%. However, inserting the probe was painful in 21% because of the nasal irritation. Due to belching and bloating the helium inflow caused some discomfort in 93%, but just slightly in most cases. Sixty-nine percent had no problems to let out the gas; it was a little uncomfortable in the others.

4. Discussion

The total measurement time in this study was about 45 minutes. In a regular esophageal manometry with adaptation phase, 10 liquid swallows and pull-through procedure, the measurement time can be estimated at 15 minutes with a total of 600 mL helium inflow. The study shows that an inflow of helium up to 2 L will be well tolerated. The major side effects are depended on the catheter probe and the positioning of it. In our experience and after a large number of manometric examinations in the clinical praxis the volume of gas does not lead to negative impacts on the examined patients.

The normal mean values in gas-perfusion manometry are comparable to the values based on other established methods of esophageal manometry. In the present study there apply the mean values and their standard deviation. When comparing various normal values, it is necessary to consider the indicated scattering, for example, standard deviation, percentiles, or range.

The distal wave amplitude is 105 ± 29.2 mmHg versus 30–180 mmHg.^[9] At the measuring points 11 and 5 cm above LES the amplitude is 99 ± 25.9 and 111 ± 31.1 mmHg versus 84 ± 31.8 and 103 ± 42.3 mmHg (10 and 5 cm above LES).^[10] At 10 cm above LES, 104 ± 44 and 102 ± 51 mmHg have been found for liquid and viscous swallows using solid-state catheters.^[11] The propagation velocity, resp. wave progression, is 4.1 ± 1.13 cm/s versus 2 to 8 cm/s.^[9] Blonski et al^[11] found a higher amplitude for liquid swallows at 10 cm above LES, and a higher propagation velocity between 10 and 5 cm, compared with viscous swallows, but no difference in duration. We could confirm the increase of amplitude in the distal esophagus,^[10,11] and found an increase in velocity, but not any difference in liquid swallows compared with more consistent swallows.

The parameters of LES are at the lower limit of the previously published normal range: resting pressure is 13.6 ± 4.17 mmHg versus 10 to 45 mmHg,^[9] 15.0 ± 7.1 resp. 23.3 ± 12.6 mmHg (water-perfused and solid-state),^[12] and the pressure after complete relaxation is 0.1 ± 0.31 mmHg versus <8 mmHg,^[9] or 3.8 and 4.3 mmHg (median, liquid, and viscous swallows).^[11] It may be the physical coupling by gas between the side holes and the esophageal wall is looser than in the esophageal body surrounded by a liquid or more consistent bolus. In present study, no differences were in LES pressure in supine position compared with upright position; but in contrast, the difference is highly significant in high-resolution manometry.^[13]

In practice, the gas-perfusion manometry with helium has advantages with regard to the costs in the use of solid-state catheters, because cheaper one-way perfusion catheters can be used. Compared with the water-perfusion manometry, the benefits are a quick readiness for use because it is unnecessary to vent the measuring system, the independence from the body position or body movements, because gas does not show mass or acceleration artefacts, and there are no hygienic problems due to the bacterial growth in residual water.

5. Conclusions

Gas-perfusion manometry with helium gives an inexpensive, well practicable method for manometric examination of the esophagus. The flow rate amounts 5 mL of helium per channel, in summary 40 mL per minute per 8 channels. The expected examination time is about 15 minutes. There are no problems with the volume of the inflowing gas. The most unpleasant sensations are belching and a feeling of slight distension.

The normal mean values are comparable to the values in other manometric procedures, for example, with water-perfusion and solid-state catheters. The distal wave amplitude is 105 ± 29.2 mmHg, the duration of contraction is 3.4 ± 0.57 second, and the wave progression is 4.1 ± 1.13 cm/s. In LES, the basal pressure is 13.6 ± 4.17 mmHg, the pressure after complete relaxation is 0.1 ± 0.31 mmHg, and the post relaxation pressure increase 71.7 ± 22.42 mmHg. The LES pressure is generally a little lower than the average values in water-perfusion or solid-state technique published by other authors.

While the high-resolution manometry is the well-established method for esophageal examination in gastroenterological centers, the conventional manometry with up to 10 channels, in particular with gas-perfused catheters, is still a viable option for diagnostics not least in smaller hospitals.

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