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A new anal manometry technique for assessing the functional state of the rectal sphincter apparatus

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Abstract

Objective. To develop a new modern precession strain gauge sphincterometer for assessing the functional state of the sphincteric apparatus of the rectum in the normal state with an increase in the accuracy of the results of recording the absolute pressure values generated in it.

Materials and methods. The results of anal manometry (sphincterometry) of 90 patients (45 men and 45 women) aged 18 to 72 years without anorectal pathology and manifestations of anal incontinence were analysed to establish normal indicators of the state of the sphincteric apparatus of the rectum using a newly developed modern precession strain gauge sphincterometer.

Results. The conducted sphincterometric study allowed to establish the following indicators of the functional state of the sphincteric apparatus of the rectum in the norm for men: sphincter tone (26.7 ± 2.2) mm Hg, maximum contraction (35.6 ± 5.1) mm Hg, gradient of voluntary contraction (9 ± 4.9) mm Hg, cough test (36.5 ± 4.9) mm Hg, test with straining (38.2 ± 3.5) mm Hg; for women: sphincter tone (23.3 ± 2.5) mm Hg, maximum contraction (31.3 ± 4.3) mm Hg, voluntary contraction gradient (8.0 ± 3.6) mmHg, cough test (31.6 ± 3.0) mmHg, and expiratory test (32.4 ± 3.0) mmHg.

Conclusions. The proposed method of anal manometry allows for a detailed study and objective assessment of the functional state of the sphincteric apparatus of the rectum in men and women in the normal state according to such indicators as sphincter tone and maximum contraction, gradient of voluntary contraction, as well as cough and straining tests.

Key words: anal manometry; sphincterometer; sphincteric apparatus of the rectum.

Anal continence is ensured by the coordinated interaction of the receptor apparatus of the rectal sensory zone and anal canal, the leading nerve pathways of the spinal cord and brain with the muscle structures of the external and internal sphincters. The pressure created by the sphincteric apparatus of the rectum at rest is due to the tonic activity of both the smooth muscles of the internal sphincter and the transverse striated muscles of the external sphincter. Its value is determined by the work of the internal sphincter by 70 – 80% and only by 20 – 30% – by the work of the external sphincter. But voluntary contraction is carried out mainly by the transverse striated muscles of the external sphincter and pelvic floor muscles [1].

An objective assessment of the functional state of the rectal sphincter apparatus is primarily necessary to identify the mechanism of anal incontinence and choose a method of its correction, as well as to compare existing methods of treating various diseases of the anal canal and rectum [2].

The most common method of studying the function of the external and internal anal sphincters is sphincterometry, which allows to assess their total contractile activity and can be mechanical (tonic) and balloon (manometric). Mechanical (tonic) sphincterometry is based on the strain–gauge principle of operation, i.e. sphincter contractions are converted into an electrical signal using a piezoelectric element. Balloon (manometric) sphincterometry involves determining the pressure inside a balloon filled with water or air and connected to a measuring device that is inserted into the anal canal [3]. The disadvantage of this technique is that it is impossible to assess the involvement of the internal and external sphincters in the tonic tension, and that quantitative assessment of pressure indicators is possible only at rest and during voluntary contraction. In addition, this technique does not allow to calculate the gradient of voluntary contraction, i.e. the difference between the maximum sphincter force during voluntary contraction and its tonic tension [3].

An alternative to these methods is anorectal manometry using perfusion catheters (profilometry), but it takes longer to perform and is much more expensive than sphincterometry [4].

Anorectal manometry has advanced considerably over the past decade, as evidenced by the advent of high–resolution or three–dimensional high–definition anorectal manometry, which allows for the assessment of several anorectal functions, including rectal–anal reflex activity, anal sphincter function, recto–anal coordination during simulated defecation, and rectal sensory function. Three–dimensional high–definition anorectal manometry can help in the diagnosis of functional anorectal disorders, but there are few data comparing asymptomatic and symptomatic courses [5, 6]. In addition, the clinical impact of the results obtained

with these new technologies has yet to be well studied and analysed [7, 8].

Therefore, the relevance of the problem of anal continence is quite high and encourages the development and implementation of new modern effective methods of anal manometry in clinical practice to assess the functional state of the sphincteric apparatus of the rectum in normal conditions and in various proctological pathologies.

The aim of the study was to develop a new modern precision strain gauge sphincter to assess the functional state of the sphincteric apparatus of the rectum in the normal state with an increase in the accuracy of the results of recording the absolute pressure values generated in it.

Materials and methods

In August 2023, the Proctology Department of the Khmelnytsky Regional Hospital developed and introduced into clinical practice a precession strain gauge sphincterometer for assessing the condition of the rectal sphincter (Certificate of Copyright Registration for a work No. 123235 dated 25.01.2024 issued by the Ukrainian National Office of Intellectual Property and Innovations).

The newly developed sphincterometer (*Fig. 1*) differs in that it contains a cylindrical spring sensor mounted in the body, which allows recording the pressure of the rectal sphincter, and the sensor is made in the form of a cylinder with a rounded end. The internal part of the sensor is a steel or plastic spring of cylindrical shape, on the surface of which there are four strain gauges that create overlapping measurement zones. Each strain gauge is connected to an electronic module of the sphincterometer. The internal cavity of the spring is filled with polyurethane foam. The rigidity of the structure is provided by a steel rod running along the entire sphincter. An electronic thermometer for obtaining the patient's body temperature is located in the nasal part, connected to the electronic module of the sphincterometer.

The sphincterometer includes a glass holder with a disinfectant liquid heated to 36 °C (*Fig. 2*).

The sphincterometer is heated to the set temperature in the liquid, which is indicated by colour indicators, and the patient does not feel contact with a cold object, which prevents a possible negative impact on the test results. The sphincterometer and the holder are connected to an electronic unit, which in turn is connected to a personal computer (PC) and transmits data to the monitor via specialised software (*Fig. 3*).

For sphincterometry to determine the normal parameters of the rectal sphincter apparatus, 90 patients were involved: 45 (50%) women and 45 (50%) men. The age of the patients ranged from 18 to 72 years.

Before anal manometry, all 90 patients underwent a proctological examination to exclude possible anorectal pathology that could lead to a dysfunctional state of the rectal sphincter, including examination of the perianal area, finger examination of the rectum and rectomanoscopy. None of the examined patients had any pathology of the anal canal or rectum that could lead to a violation of the functional state of the sphincteric apparatus.

To perform anal manometry, a latex protective coating lubricated with a special gel was applied to the working part of the sphincterometer with strain gauge sensors and carefully inserted into the anal canal. Sphincterometry was started 1 min after insertion of the working part of the sphincterometer into the anal canal – the time required for the patient to adapt to the examination and for the anal reflex caused by the introduction of the device to subside.

During the sphincterometry, all patients had the following indicators of the functional state of the sphincter apparatus determined (in mm Hg): sphincter tone, maximum contraction, gradient of voluntary contraction, and cough and expectoration tests were performed. The data from the strain gauges were transmitted to an electronic unit that processed and analysed the necessary information and, through a connection to a PC and special software, allowed the information to be presented in the form of four graphical images.

Statistical analysis of the data was performed using the SPSS Statistics subscriptional trial software (licence No L–

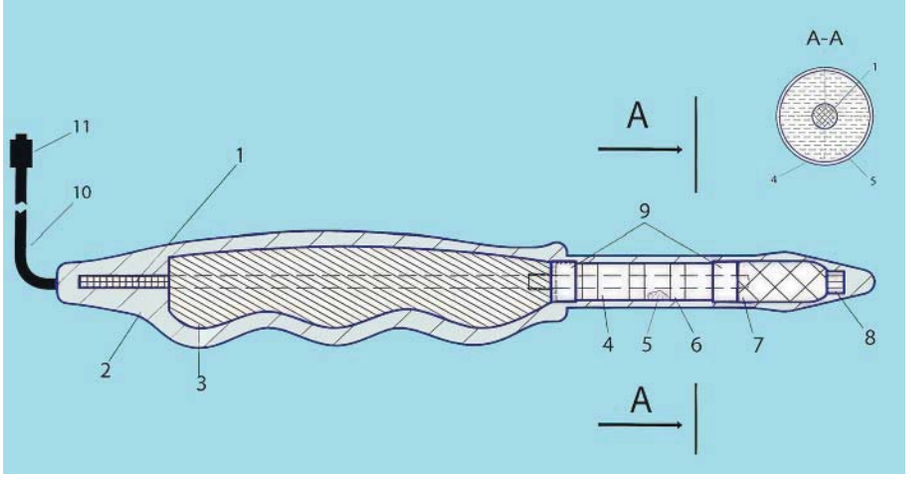

Fig. 1.
Schematic representation of a sphincterometer: 1 - steel rod; 2 - silicone cover; 3 - plastic force element of the case; 4 - steel (plastic) spring; 5 - polyurethane foam; 6 - strain gauges; 7 - plastic "head" guide; 8 - thermometric sensor; 9 - fixing couplings; 10 - data cable; 11 - mini USB plug plug for connection to the electronic unit.

CZAA–BHG85V). The sample size was 90 patients (45 men and 45 women).

To describe the indicators of the functional state of the sphincter, their mean value (MV), standard deviation (SD), as well as the minimum (min.) and maximum (max.) values were used.

The presence of statistically significant differences between the mean values of indicators in the groups of men and women was determined using the ANOVA (Analysis of Variance) method. The critical level of statistical significance was 0.05.

Results

The sphincterometric study made it possible to establish the following normative indicators of the functional state of the rectal sphincter apparatus in men: sphincter tone – from 22.4 to 31.4 mm Hg, NW indicator (26.7 ± 2.2) mm Hg, maximal contraction – from 29.5 to 48.6 mm Hg, NW index (35.6 ± 5.1) mm Hg, gradient of voluntary contraction – from 2.4 to 25.1 mm Hg, NW index (9.0 ± 4.9) mmHg, cough test – from 30.4 to 46.5 mmHg, NW index (36.5 ± 3.5) mmHg, expiratory test – from 29.6 to 45.3 mmHg, NW index (38.2 ± 3.5) mm Hg; in women: sphincter tone – from 19.5 to 29.9 mm Hg, NW index (23.3 ± 2.5) mm Hg, maximum contraction – from 23.9 to 45.6 mm Hg, NW index (31.3 ± 4.3) mm Hg, gradient of voluntary contraction – from 1.8 to 22.0 mm Hg, NW index (8.0 ± 3.6) mm Hg, cough test – from 22.8 to 38.2 mmHg, NW index (31.6 ± 3.0) mmHg, test with exertion – from 26.5 to 41.7 mmHg, NW index (32.4 ± 3.0) mmHg. The obtained data of anal manometry of men and women differed statistically significantly *(see Table)*.

Graphically, the indicators of the functional state of the rectal sphincter during anal manometry were represented by curves that reflected their minimum, maximum and average values, as well as the time of the examination (*Fig. 4*).

Discussion

The proposed method of anal manometry (sphincterometry) allows an objective assessment of the functional state of the external and internal sphincters of the rectum in men and women.

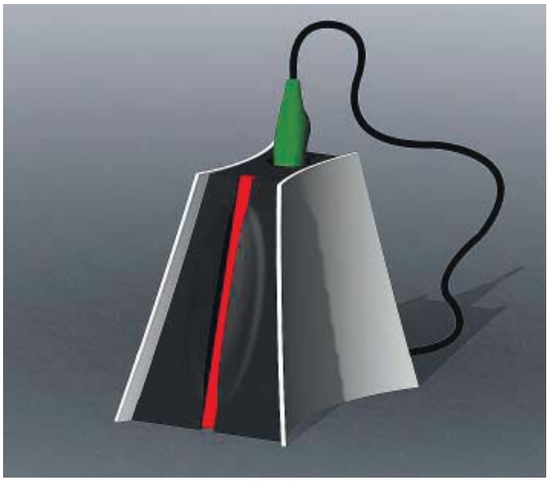

Fig. 2.
A glass stand with a working part inside.

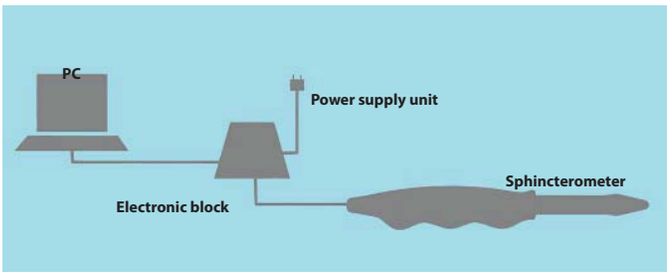

Fig. 3.
Block diagram of the newly developed sphincterometer.

Sphincter tone (tonic force), recorded at the beginning of the examination, characterises mainly the force of tonic contraction of smooth myocytes, which determines the state of the internal anal sphincter, and to a lesser extent the force of tonic contraction of the transverse striated muscles of the external anal sphincter.

The indicator of maximum contraction (force) most accurately indicates the functional state and contractile capacity of the transverse striated muscles of the external anal sphincter and pelvic floor muscles.

The possibility of calculating the gradient of voluntary contraction of the anal sphincter as the difference between its maximum contraction and tonic effort is quite important in the proposed method of anal manometry, which, unfortunately, is not possible during balloon sphincterometry [3].

Data of statistical analysis of indicators of the functional state of the sphincteric apparatus of the rectum in normal patients

Indicator (mmHg)	Statistical information								p<
	women (n=45)				men (n=45)				
	MV	SD	min.	max.	MV	SD	min.	max.	
Тонус	23,3	2,5	19,5	29,9	26,7	2,2	22,4	31,4	0,001
Максимальне скорочення	31,3	4,3	23,9	45,6	35,6	5,1	29,5	48,6	0,001
Градієнт вольового скорочення	8,0	3,6	1,8	22,0	9,0	4,9	2,4	25,1	0,001
Кашльова проба	31,6	3,0	22,8	38,2	36,5	3,5	30,4	46,5	0,001
Проба з натужуванням	32,4	3,0	26,5	41,7	38,2	3,5	29,6	45,3	0,001

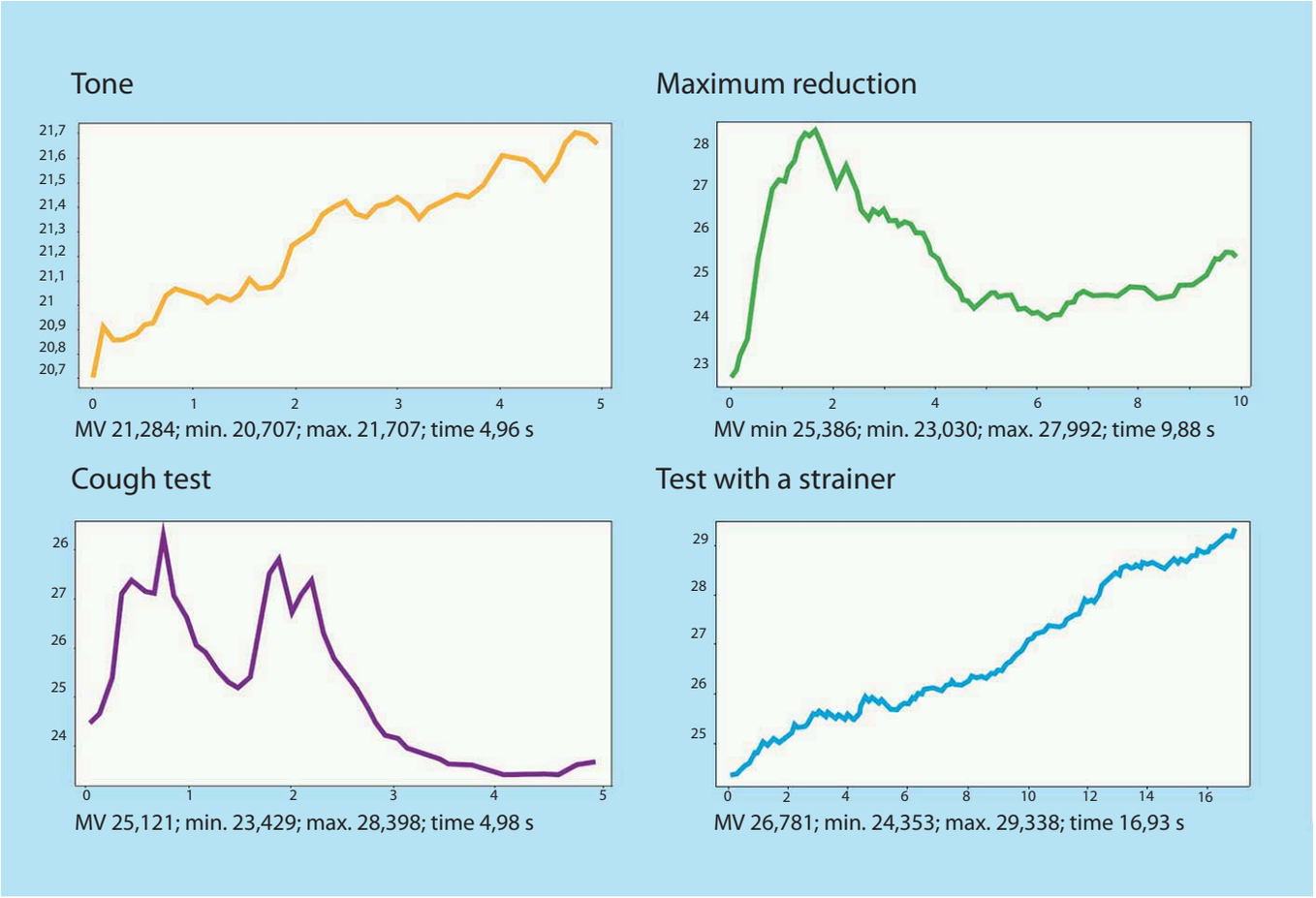

Fig. 4.
Graphical representation of the functional state of the rectal sphincter apparatus according to anal manometry.

Indicators of two functional tests (coughing and straining) objectively and fully characterise the state of both rectal sphincters and pelvic floor muscles, as well as the anterior abdominal wall, and give grounds to judge the overall functional state of the rectal sphincter apparatus, which, unfortunately, cannot be determined by existing methods of strain gauge and balloon anal manometry [3]. In addition, the proposed method of sphincterometry is much cheaper and faster to perform than existing methods of perfusion anal manometry (profilometry) [4].

Conclusions

1. The proposed method of anal manometry allows for a detailed examination and objective assessment of the functional state of the sphincteric apparatus of the rectum in men and women in normal conditions, based on such indicators as sphincter tone and maximum contraction, gradient of voluntary contraction, as well as cough and expectoration tests.

2. The newly developed sphincterometry technique is indicated for assessing the functional state of the rectal sphincter apparatus in various variants of anorectal pathology and in different periods after surgical interventions for it, which makes it possible to use it widely in proctological practice.

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Conflict of interest. There are no potential or apparent conflicts of interest related to this manuscript at the time of publication and none are anticipated.

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