

ORIGINAL ARTICLE

# The effectiveness of corticovisceral connections recovery using biofeedback in children after surgical treatment of rectal atresia

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## Abstract

**OBJECTIVE:** The effectiveness of anal sphincters electric stimulation based on Biofeedback was assessed using electromyography (EMG) and sphincteromanometry data, which characterize inotropy of sphincters.

**METHODS:** 27 children aged from 6 to 15 years (17 boys and 10 girls) were observed. All the patients underwent the course of electrostimulation of anal sphincters with Biofeedback and stimulator (Electronic incontinence stimulation “EIC 5000”, “Dr. Rowedder biomedizinische Gerate” Incomp., Germany). The effectiveness of corticovisceral regulation recovery was assessed using sphincteromanometry and electromyography of rectal sphincters (turn-amplitude analysis). The course of therapy included 10–15 daily (except the weekends) sessions, 10–20 minutes in length.

**RESULTS:** The more pronounced results of increase of both anal sphincters resting pressure and anal sphincter pressure during voluntary contraction of anal sphincters after performed treatment course with Biofeedback application were obtained by comparison the results of anal sphincter pressure shift in patients who underwent electrostimulation with and without Biofeedback technique.

**CONCLUSIONS:** Therapeutic effect of Biofeedback technique is based on the recovery of corticovisceral connections, responsible for defecation control, and leads to anal sphincter pressure increase both at rest and during voluntary contraction of anal sphincters.

## Abbreviations:

electromyography (EMG); pressure, expressed in millimeters, water gauge (mm wg)

## INTRODUCTION

The treatment of children with anorectal malformation remains one of the most complicated problems in pediatric surgery. Treatment success depends on the type of abnormality, the degree of violation of rectum nervous regulation, timeliness and correct choice of surgery mode and the severity of rectal sphincter defect (Clermidi *et al* 2013; Peeraully *et al*

2014; Stenström *et al* 2014). Encopresis is one of the adverse effects of operation being social and medical problem (Ergun *et al* 2010). Electrostimulation of anal sphincters is widely used as nonsurgical method of encopresis treatment (Hasselbeck & Reingruber 2012; Kapuller *et al* 2014). This method is used in the Republic of Belarus since 2002. Low effectiveness of local electrostimulation made us implement methods of electrical stimulation which simulate natural

processes of feedback in the whole organism. Afferent signals (input) to brain are formed at the level of target organ receptors in this case. Signals are processed at different brain levels, compared to basic brain information and delivered to target organ (output) after decision making. All the changes in structure and function of target organ are controlled by brain according to above-mentioned scheme.

Systems of electrostimulation with Biofeedback (Chiarioni *et al* 2006; Hart *et al* 2012) allow handling physiological parameters of target organ in real-time mode (in terms of the matter in hand we are speaking about anal sphincter pressure). Therapeutic intervention is corrected according to obtained results. Usually the components of therapeutic and diagnostic hardware are combined in «Biofeedback» devices (Hart *et al* 2012). The treatment effect of the method is based on the recovery of corticovisceral connections, responsible for defecation control. Thus, the method contributes to social adaptation of the child. The technique is similar to computer games. Current values of physiological parameters are displayed on the monitor. In respect to rectal stimulation, willed impact on concrete group of muscles takes place during Biofeedback usage, leading to activation of concrete functional system, which includes receptors in rectal region, afferent and efferent pathways between rectal region and the network of brain neurons as well as concrete brain areas responsible for the control of this function. Electrical parameters of physiological state of the subject are delivered by Biofeedback contour. Output signal in every given patient is automatically corrected using this information. The study was aimed at assessing the effectiveness of anal sphincters electric stimulation based on Biofeedback using electromyography (EMG) and sphincteromanometry (Caldaro *et al* 2012; Keshtgar *et al* 2015) data, which characterize inotropy of sphincters.

## MATERIAL AND METHODS

Registration of rectal pressure was performed using device for sphincteromanometry (YD-Incorp., Minsk). The patient takes up lateral position on the side of the bed. Endotracheal tube is inserted to patient's anus; the proximal balloon is set at the level of internal anal sphincter and distal one serves as fixative. Then 10 ml of water is introduced into every balloon through three-channel valve. Then three-channel valve of proximal balloon is switched to new position, and the water from the balloon squeezes out and goes up. The height of water column in the tube corresponds to anal sphincters' pressure in mm wg. 27 children aged from 6 to 15 years (17 boys and 10 girls) were observed using this device. They had different reasons of encopresis: functional megacolon (14 children), state after surgical treatment of Hirschsprung's disease (5 children) and state after surgical treatment of anorectal abnormalities.

All the children underwent the course of electrostimulation of anal sphincters with Biofeedback and stimulator (Electronic incontinence stimulation "EIC 5000", "Dr. Rowedder biomedizinische Gerate" Incorp., Germany). Treatment was performed using complex hardware, including computerized device with Biofeedback "STIMBOS" (BGUIR Incorp., Minsk), sphincteromanometer (YD-Incorporation, Minsk), electromyograph and the set of rectal transducers for pressure and electromyogram registration. The course of therapy included 10–15 daily (except the weekends) sessions, 10–20 minutes in length. Treatment was started in 5 plus children. Children under 5 years of age are afraid of the technique because of the need of foreign matter injection into rectal ampulla. The technique is explained to children of 5 years and upward while playing. Sometimes there are nociceptive reactions in children during manipulations because of the lack of information about the consequences of complicated techniques that is why electrostimulation session should be started only after explanation. The design of diagnostic and treatment technique in children consists of the sequence of stages. First of all the treatment task and possible results are discussed in detail with the patient. Children willingly sense tasks in the form of computer game, especially when the patient tries to cure the disease himself. Then the significance of conscious accomplishment of manipulations (rectal sphincters contraction and keeping contracted within the mode displayed on the computer) is explained to the patients. Electromyogram of rectal sphincters is constantly registered during the manipulation. Information on the correctness of exercising (myogram analogue curves) is displayed as graphically (for adults) or in playing mode (for children). Patient analyzes the information and corrects power and duration of rectal sphincters contraction. Participation of patient in the process is important moment of the therapy. The patient actively and consciously participates in the treatment (this method corresponds to recommendations of Hippocrates and Avicenna).

## RESULTS

82 patients with postoperative anal incompetence were treated in Republican Surgical Centre for Children (Minsk, Belarus) in 2002–2014. 40 (48.2%) of them were boys and 42 (51.8%) girls, aged from 1 to 16 years. Patients were divided into 3 groups: children with functional megacolon (i.e. patients who did not need surgery of anal sphincter area); children after surgical treatment of Hirschsprung's disease; children after surgical correction of anorectal abnormalities. So, patients from 2<sup>nd</sup> and 3<sup>rd</sup> group underwent surgical treatment of anorectal pathology before admission to hospital. Encopresis was the main complaint in 60% of children. All the complaints were discussed in detail with parents.

Functional parameters of rectal pressure were measured using sphincteromanometry. It shows inotropic efficiency of external anal complex muscles during electrical stimulation without Biofeedback technique. Obtained data are presented in Table 1.

50 ml of air were carefully (for 1 minute) injected into rectum using Janet's syringe after completion of three manipulations presented in the Table 1. Three children with functional megacolon had positive rectoanal reflex: at first the increase of pressure caused by contraction of external anal sphincter, then decrease of pressure caused by relaxation of internal anal sphincter and finally recovery of pressure to basal level. There was no reaction of internal anal sphincter to air injection in children with organic diseases of rectal region. Performed studies showed that electrostimulation of anal sphincters was effective in 85.7% of cases. There are literature data on sufficiently high efficiency of this treatment technique – from 60% to 100% (Clermidi *et al* 2013; Peeraully *et al* 2014; Stenström *et al* 2014). Thus the obtained data are in agreement with literature ones. According to literature, anal sphincter resting pressure in healthy children is  $387.6 \pm 13.7$  mm wg, and anal sphincter pressure during voluntary contraction –  $731.7 \pm 39.4$  mm wg (Ergun *et al* 2010; Keshtgar *et al* 2015). Therefore, these parameters were below the line in the examined children. Anal sphincter pressure increased after the session of electrostimulation, but did not meet the normal ones.

That is why classic technique of electrostimulation was complemented with Biofeedback technique. Biofeedback efficiency was controlled by EMG and sphincteromanometry. Mean amplitude of signals during external anal sphincter contraction reached  $300 \pm 59 \mu V$  before treatment. A gradual increase of bioelectrical activity was observed after electrostimulation of *m. sphincter ani externus* with the maximum amplitude after 15 minutes of stimulation. Turn-amplitude analysis significantly verified the effectiveness of performed Biofeedback manipulation. At first EMG parameters

are registered within the process of anal sphincter muscles contraction. Software system SpectraPRO v 3.32.17 was used for EMG signal registration and processing (Osipov *et al* 2002). Software system SpectraPRO provides dual-channel recording of signals and their spectral processing. Spectral processing of signals was performed in real-time mode in order to demonstrate EMG results to children. Patients evaluated the power of muscular contraction, their spectrum and/or spectrogram displayed in graphic colored form. Spectrogram was used for more spectacular demonstration of events to children. It was found that the highest EMG signal during rectal sphincters contraction is observed at 50–150 Hz. Study results allowed assessing the dynamics of muscular complex state within the treatment course. It is all about the analysis of the process of anal sphincter muscles contraction, because it gives a possibility to estimate peculiarities of rectal pressure and EMG signal during voluntary contraction, conscious retention of sphincters in contracted state and relaxation of sphincters (Table 2).

The more pronounced results of increase of both anal sphincter resting pressure and anal sphincter pressure during voluntary contraction of anal sphincters after performed treatment course with Biofeedback application were obtained by comparison the results of anal sphincter pressure shift in patients who underwent electrostimulation with (Table 2) and without (Table 1) Biofeedback technique. All the patients had positive results. These ones included complete remission of the disease or statistically significant decrease in the number of encopresis episodes, when the patients were satisfied with their quality of life after the treatment. 24 patients were included in long-term (eight months) follow up. 12 patients had steady treatment effect. The other 12 reported the relapse in two months after the end of treatment. Therefore, it is necessary to improve this treatment method. We suppose that special attention should be paid to individual selection of electrical stimulation modes and determination of Biofeedback techniques.

**Tab. 1.** Anal sphincter pressure after electric stimulation.

Parameters	1 <sup>st</sup> group	2 <sup>nd</sup> group	3 <sup>rd</sup> group
Anal sphincter resting pressure (mm wg)	125.0±24.71	111.7±35.10	100.7±26.41
Anal sphincter pressure during voluntary contraction of anal sphincters (mm wg)	208.9±26.90	206.1±52.74	178.1±32.74
Anal sphincter pressure during conscious retention of anal sphincters (mm wg)	315.5±90.52	275.8±41.55	228.1±52.74

**Tab. 2.** Anal sphincter pressure after electric stimulation with Biofeedback.

Parameters	1 <sup>st</sup> group	2 <sup>nd</sup> group	3 <sup>rd</sup> group
Anal sphincter resting pressure (mm wg)	178.0±45.8	167.2±23.6	140.7±34.44
Anal sphincter pressure during voluntary contraction of anal sphincters (mm wg)	216.3±26.90	210.5±23.74	154.1±22.54
Anal sphincter pressure during conscious retention of anal sphincters (mm wg)	334.4±40.23	287.8±38.49	276.1±48.43

## CONCLUSIONS

According to obtained data and results of other scientists (Hasselbeck & Reingruber 2012), the use of Biofeedback technologies in patients with rectal atresia is accompanied with reduction of rehabilitation terms in 2–2.5 times, lowers drug load in 1.5–2 times and effectively activates reserves of brain and the whole organism in enhancement of self-regulation processes. Patients with “new” surgically formed anal canal are in strong physiological need of neuronal networks formation in sensorimotor brain regions, trained to control the tone of anal sphincters. The more conscious the muscular system of anal sphincters will be used, the faster neuronal networks and synapses will be formed in the brain, increasing the chance of recovery of normal sphincters function.

Therefore, Biofeedback technique is effective in the treatment of rectal atresia in children. This method is non-invasive, cheap and practically does not have contraindications. The inability of patient to realize the design of the technique is a relative contraindication, because it is accompanied with stress within the process of manipulation. This lack of the technique is mainly determined by the age and the level of intelligence. Therapeutic effect of Biofeedback technique is based on the recovery of corticovisceral connections, responsible for defecation control, and leads to anal sphincter pressure increase both at rest and during voluntary contraction of anal sphincters.

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