

Efficacy Control of Functional Electrostimulation of Pelvic Floor Muscles after Radical Prostatectomy

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Introduction

According to the data of Lithuanian Cancer Registry the number of prostate cancer cases (125.1 per 100000 of the population) exceeded that of trachea and lung cancer cases (85.1 per 100000 of the population) in the year 2005 [1]. Unfortunately, only 55% of prostate cancer cases diagnosed for the first time is non-wide-spread cancer [2]. In this case radical prostatectomy or radical radiation therapy proves an effective method of treatment. One of the most prostrating adverse effects of radical prostatectomy is urinary incontinence. According to the data of the European Association of Urology, considerable urinary incontinence is found in 0-15.4% and slight urinary incontinence may be found in 4-50% of men after surgery [3]. Urinary incontinence after radical prostatectomy is mostly conditioned by the damage of the striated external sphincter. The function of this sphincter can be partly compensated by the pelvic floor muscles (PFM). Therefore increasing their force and coordinating their activities can decrease urinary incontinence. With this aim in view physical exercises worked out by A. Kegel and functional electrostimulation (FES) are recommended. It has been experimentally established by quite a few researchers long ago that FES produces good results without any adverse effects treating urinary incontinence [4], strengthens PFM after radical prostatectomy [5]. Good results are reported when applying jointly both physical exercises and FES following radical prostatectomy [6].

Presently FES is performed establishing the value of current on the visual fact of PFM contraction or the level of discomfort. The aim of our research is to quantitatively assess the efficacy of FES after radical prostatectomy in conditions of urinary incontinence. More convenient FES methods and observation of the FES process are proposed in the paper. The study of patients with their individual differences enables one to detect certain tendencies and their connection characteristics of the ailment.

Methods

The complex of means and actions of the FES efficiency control consists of the scheme of electrode placement and the perineometer (a measuring device used to measure PFM contraction changes), as well as procedures and possibilities of using the perineometer.

The electrode placement is shown in Fig. 1. A surface electrode of sufficient size to decrease the FES current density is glued below the scrotum. An anal electrode single or anal longitudinal electrode double (both leads connected together) is inserted into the anus. After connecting up the electrostimulator the electric current starts flowing between these electrodes. The way of this current through the PFM is shown in Fig. 1.

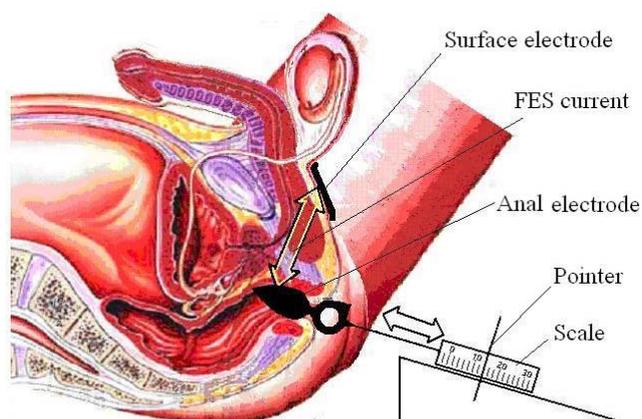


Fig. 1. The scheme of electrode placement, the way of the FES current and the principle of measuring the contraction volume of the PFM

Under the effect of the FES current the PFM start contracting and they relax when the current is discontinued. PFM contraction manifests itself visually by suction of the anal sphincter (together with the anal electrode). This longitudinal movement forward can be

measured by means of the perineometer shown schematically in Fig. 1. The operation of the perineometer is based on the following principle: a ruler is attached to the moving anal electrode and according to its advance in the direction of electrode movement the contraction volume of the PFM can be assessed.

The perineometer worked out by the authors is attached to the anal electrode. It gives the possibility by means of one attachment to measure the reaction volume of the PFM before, during and after FES. The results of measurements of the same type makes their intercomparison possible, as well as enables one to express the efforts of the voluntary muscle contraction in terms of the equivalent of electric current.

The construction of the perineometer is a simple one. Its basis consists of a directive tray along which moves a slide-block equipped with a millimetre indicator scale. A perpendicular pointer installed between the sides of the tray makes the reading muscle contraction value possible. A stick joined with the slide-block through a semi-elastic coupling ends in a clip. To convey the suction movement of the anus the clip is clipped to the handle of the anal electrode inserted into the anus.

Measurements before, during and after the session of FES are performed with the patient lying on the back with his legs spread and flexed in the knees. The electrodes are attached to the body of the patient, as shown in Fig. 1. The leads of both electrodes are connected to the electrostimulator used. The perineometer mentioned is clipped to the handle of the anal electrode. Its position with respect to the plane surface, the patient is lying on, is such as to make the movement of the stick occur along the axis of the anal electrode. The directive tray was fixed in such a position that would allow the slide-block with an indicator scale to move within the boundaries of the indicator scale. Equipping FES and the site of measuring in such a way enables one:

1. To determine the dependence of the value of reaction of PFM on the FES current amplitude.
2. To carry out the measuring of visible changes in voluntary contraction of PFM before FES.
3. To carry out a session of FES that allows to measure the reaction value of PFM conditioned by the FES current amplitude.
4. To carry out the measuring of visible changes in voluntary contraction of PFM after FES.

Before starting the FES procedure the sensitiveness of the patient's PFM to the FES current amplitude should be determined. In the equipped FES and reaction measuring site (Fig. 1) the electrostimulator was switched on and continuously increasing the amplitude I of single FES impulses of 2.5 s duration we measured the volume of visible changes in reaction R of PFM.

This is how the dependence of muscle reaction R (in millimeters) on the FES current amplitude I (in miliampers) is determined. An example of this dependence is shown in Fig. 2. There is no visible reaction in PFM up to FES current amplitude I_{min} . After increasing the amplitude up to I_{max} muscle reaction R reaches its limit value R_{max} . Further increasing of the FES current amplitude does not increase PFM reaction but strengthens unpleasant sensations. The obtained amplitude value I_{max} of the FES

current is used during the FES session. The sensitiveness of the patient's PFM is expressed by the ratio $R_{max} / (I_{max} - I_{min})$. The values obtained are individual and they are associated with the properties and condition of the PFM.

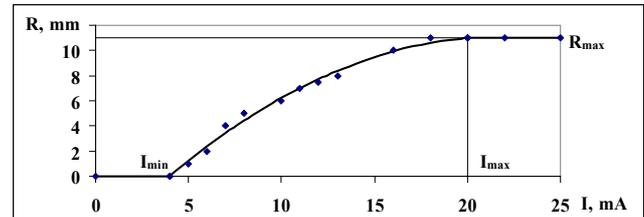


Fig. 2. An example showing the dependence of reaction R of PFM on the amplitude I of FES current

To determine the effect of FES the measuring of visible changes in contraction of the stimulated muscles is used, the patient performing voluntary contractions of PFM before and after FES. Voluntary contraction of PFM with the greatest efforts is performed in accordance with the requirements of Kegel's physical exercises [7]. To decrease muscle fatigue contraction time is limited to 1-2 s. To decrease subjectivity and increase the validity of the results obtained 10 contractions are made.

Before FES session the following parameters should be known: on time, off time, ramp time and FES current amplitude I_{max} . The duration of the FES session or the number of impulses to be delivered are prescribed in advance.

The surface electrode 100x50 mm and the anal electrode double Anuform (both leads connected together) of the Neen Healthcare firm were used for the research done [8]. For FES the electrostimulator Stimul-1 [9] was used. For FES sessions the following regimen was set: 20 impulses with on time 10 s, off time 50 s, amplitude ramp time 1 s. The impulse amplitude I_{max} was established in accordance with muscle reaction dependence of a concrete patient on the FES current amplitude.

Results

The perineometer was used in treating 7 patients who had been sent for treatment by means of FES because of urine incontinence after radical prostatectomy. The data regarding contraction of their PFM before, during and after FES have been used in this paper to illustrate the properties and possibilities of the perineometer. The data have been obtained according to the scheme, as shown in Fig. 1. The data: I_{max} = 18-44 mA and sensitiveness of PFM 0.27-1.26 mm/mA in the group of 7 patients have been obtained.

Before FES and after FES the patients performed 10 voluntary contractions of PFM done with the greatest efforts. The duration of each contraction was 1-2 s. The contingent of the patients has shown that various cases are possible. This is evident from Fig. 3. The average data of three patients (N=3) were smaller after FES (2) than before FES (1) throughout the 10 contractions. This shows that muscles get fatigued by FES. The average data of the other four patients (N=4) were slightly bigger after FES. This might be explained by the training effect of FES induced contractions.

During FES, when PFM are contracted by compulsion under the influence of FES current, muscle contraction value should be nearly the same at the beginning of the FES session. Still, as shown in Fig. 4, in the course of 20 FES impulses there occurs a slight decrease in compulsory muscle contraction, and this is indicative of muscle fatigue. During the pauses between stimulating impulses the muscles do not manage to recover completely. Greater values of voluntary contractions (Fig. 3) correspond to greater values of muscle reaction under the influence of FES (Fig. 4).

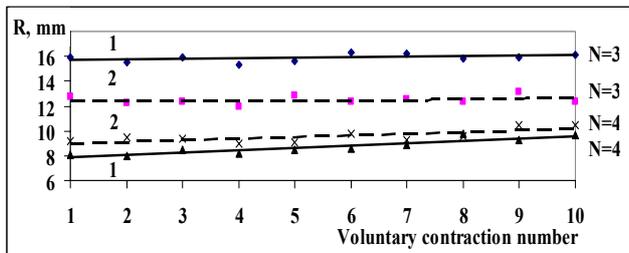


Fig. 3. Reactions of 10 voluntary contractions of PFM of two groups (N=3) and (N=4) of patients before FES (1) and after FES (2)

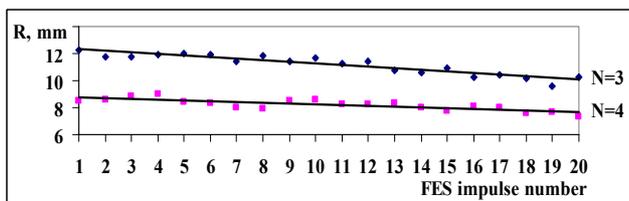


Fig. 4. Reactions of 20 contractions of PFM of two groups during FES

A small number of patients studied does not allow us to assert yet the presence of a definite relationship between manifestations of the course of ailments and the effect of FES. The data of research available, however, allow us to single out several possible tendencies. They may be associated with changes in reaction values of PFM. This might serve as presumptions for choosing a more effective FES regimen for separate patients.

Discussion

In cases of ailments with urinary incontinence specially for strengthening PFM by means of FES electric regimens, established according to their efficacy, are used. Recommendation may serve an example [10]. A great variety of electrostimulators available allows one both to perform muscle strengthening sessions and to use them for research purposes without any difficulties. The electrostimulator Stimul-1, verified well in medicinal practice, has been chosen for the research done [9]. This stimulator distinguishes itself by the following positive properties: direct control of the electric current, the ratio of on time and off time durations, decreases muscle fatigue, simple and easy to use.

In the classical tradition for strengthening PFM by way of electrostimulation surface electrodes and anal electrodes double are used [11]. Surface electrodes can be glued to the coccyx and in different sites the pelvic floor. Bones and tendons may occur in the way of the FES

current and due to this the patient may be subjected to discomfort. In the case of an anal electrode double the electric current concentrates itself in the site of the anal sphincter. With drawing away from the anal sphincter the effect of FES current decreases. With an aim of increasing the effect of FES current for the PFM stimulated we propose to use a combination of surface and anal electrodes that allows to direct the way of the electric current immediately at the muscles along the pelvic floor (Fig. 1). Restricting oneself to anal electrode double (without a surface electrode) with a perineometer proposed by us joined to it, one would have a widely used, but already controlled, case of FES.

The well-known perineometers PFX2A, 9300A, etc. [12] of the firm Cardio Design Pty Ltd. (Australia), based on the measuring of air pressure changes in the anal elastic sensor, operate on manometer principle and give measuring results in the form of water column length expressed in centimeters. They can be used doing Kegel's exercises before and after FES. They operate in conditions different from those of FES. These perineometers are not acceptable for our methods used, since they do not suit for measuring during FES, because instead of sensor there should be the anal electrode of electrostimulator during FES. Thus it is not possible to obtain information as to the reaction of PFM. Perineometers of manometric type would be suitable and universal if their anal sensors were conductive to electric current and could serve at least as anal electrode single at the same time. The use of electromyographic perineometer during FES impulse is problematic [13] because of great FES and small currents ratios at various sites of the muscles. The perineometer attached to the anal electrode, proposed by the authors, enables one by means of a single connection to measure the volume of reaction of PFM before, during and after FES. The results of measurements of the same type allow their intercomparison expressing the efforts of voluntary muscle contraction at some ratio in terms of electric current equivalent. The ratio may be conditioned not necessarily by recruitment of the same muscles contracting them both voluntarily and by compulsion during FES.

The use of all perineometers performing voluntary actions with maximum efforts is associated with subjective conditions. Here belong such factors, as the ability of the patients to perform voluntary muscle contractions in accordance with the requirements set, the level of motivation, fluctuation of mood and health condition, etc. It is these conditions that mostly decide the validity of measuring data. In spite of this, the methods and equipment used create presumptions and possibilities for observing and assessing the state of PFM of the patients.

Conclusions

1. A combined scheme of placement of surface and anal electrodes during FES of men's PFM after radical prostatectomy has been proposed.

2. The perineometer and the methods of using it, that ensure control of the condition of PFM of a concrete patient according to the same measurement scheme before, during and after FES, have been proposed.

3. The methods proposed enable one to accumulate statistical data aimed at clearing up the tendencies in the changes of the condition of PFM.

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The aim of the research was to quantitatively assess the efficacy of FES after radical prostatectomy in conditions of urinary incontinence. A combined scheme of placement of surface and anal electrodes ensuring a more precise way of the electric current through pelvic floor muscles and decreasing discomfort has been proposed. The perineometer, a device for measuring the reaction (exterior advance) of pelvic floor muscles under the effect of FES current (during FES session) and during voluntary contractions before and after FES session without changing the scheme of measuring, has been used. Before starting the FES session prescribed it would be preferable to establish the dependence of reaction of pelvic floor muscles of each patient on the volume of FES current used and to carry out FES session in accordance with the data obtained for each particular patient. The methods and the equipment, proposed by the authors, create presumptions for observing and assessing the condition of pelvic floor muscles of the patients. Ill. 4, bibl. 13 (in English; summaries in English, Russian, Lithuanian).

A. Бингелис, Р. Б. Кибіша, Д. Трумбьякас, А. Кришчюнас, И. К. Мицкявичюс. Контроль эффективности функциональной электростимуляции мышц промежности после радикальной простатэктомии // *Электроника и электротехника.* – Каунас: *Технология*, 2007. – № 2(74). – С. 59–62.

Цель исследования – количественная оценка эффективности ФЭС при недержании мочи после радикальной простатэктомии. Предложена комбинированная схема расположения поверхностного и анального электродов, обеспечивающая более точный путь через мышцы промежности и уменьшающая дискомфорт. Использованное устройство – перинеометр для измерения реакции мышц промежности (визуального перемещения) на воздействие тока ФЭС (во время сеанса) и при волевых сокращениях мышц перед и после сеанса ФЭС не меняя схемы измерения. Перед началом назначенного цикла ФЭС целесообразно для каждого пациента определить зависимость реакции мышц промежности от амплитуды тока ФЭС и её данными руководствоваться при проведении сеанса ФЭС. Методика и оснащение дают возможность наблюдать и оценить состояние мышц промежности. Ил. 4, библи. 13 (на английском языке; рефераты на английском, русском и литовском яз.).

A. Bingelis, R. B. Kibiša, D. Trumbeckas, A. Kriščiūnas, J. K. Mickevičius. Tarpvietės raumenų funkcinės elektrostimuliacijos efektyvumo kontrolė po radikalios prostatektomijos // *Elektronika ir elektrotechnika.* – Kaunas: *Technologija*, 2007. – Nr. 2(74). – P. 59–62.

Tyrimo tikslas — kiekybiškai vertinti FES efektyvumą po radikalios prostatektomijos esant šlapimo nelaikymui. Pasiūlyta kombinuota paviršinio ir analinio elektrodų išdėstymo schema, užtikrinanti tikslesnį srovės kelią per tarpvietės raumenis ir mažinanti diskomfortą. Panaudotas įtaisas – perineometras tarpvietės raumenų reakcijai (išoriniam poslinkiui) matuoti veikiant FES srovei (seanso metu) ir valingų sutraukimų metu prieš ir po FES seanso nekeičiant matavimo schemas. Prieš pradėdant skirtą FES ciklą tikslinga nustatyti kiekvieno paciento tarpvietės raumenų reakcijos priklausomybę nuo FES srovės dydžio ir jos duomenimis vadovautis atliekant FES seansą. Metodika ir įranga leidžia stebėti ir vertinti pacientų tarpvietės raumenų būseną. Il. 4, bibl. 13 (anglų kalba; antraukos anglų, rusų ir lietuvių k.)