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·*Original Article*·

The cavernoso-anal reflex: response of the anal sphincters to cavernosus muscles' stimulation

Ahmed Shafik[1], Ismail Shafik[1], Ali A. Shafik[1], Olfat El Sibai[2]

[1]*Department of Surgery and Experimental Research, Faculty of Medicine, Cairo University, Cairo 11121, Egypt*
[2]*Department of Surgery, Faculty of Medicine, Menoufia University, Shebin El-Kom, Egypt*

Abstract

Aim: To prove the hypothesis that cavernosus muscles' contraction during coitus affects the reflex contraction of anal sphincters. **Methods:** Electromyographic response of external and internal anal sphincters to ischiocavernosus and bulbocavernosus muscle stimulation was studied in 17 healthy volunteers (10 men, 7 women, mean aged 38.3 ± 11.6 years). The test was repeated after individual anesthetization of anal sphincters and the two cavernosus muscles, and after using saline instead of lidocaine. **Results:** Upon stimulation of each of the two cavernosus muscles, external and internal anal sphincters recorded increased electromyographic activity. Anal sphincters did not respond to stimulation of the anesthetized cavernosus muscles nor did anesthetized anal sphincters respond to cavernosus muscles' stimulation. Saline infiltration did not affect anal sphincteric response to cavernosal muscles' stimulation. **Conclusion:** Cavernosus muscles' contraction is suggested to evoke anal sphincteric contraction, which seems to be a reflex and mediated through the "cavernoso-anal reflex". Anal sphincteric contraction during coitus presumably acts to close the anal canal to thwart flatus or fecal leak. *(Asian J Androl 2006 May; 8: 331–336)*

Keywords: bulbocavernosus muscle; ischiocavernosus muscle erection; sexual act; orgasm; erectile dysfunction

1 Introduction

The mechanisms of human sexual behavior are intricate and incompletely understood [1–4]. The two cavernosus muscles, bulbocavernosus and ischiocavernosus, are the principal muscles in action during sexual intercourse [5]. The cervicocavernosus [6] and vaginocavernosus [7] reflexes are evoked during the sexual action. Penile thrusting against the cervix and vaginal distension during sexual intercourse induce reflex cavernosus muscles' contraction. Cavernosus muscles' contraction enhances both clitoris and penile erection because of the compression exerted on the deep dorsal vein of penis or clitoris and on the erectile cavernous tissue [8]. Furthermore, cavernosus muscles' contraction helps to milk the semen, which fills the penile urethra, into the vagina during penile withdrawal from the vagina after ejaculation [6, 7].

The sexual sensory signals are mediated to the sacral segments of the spinal cord through the pudendal nerve and sacral plexus, and are then transmitted to the cerebrum [9]. Also, local reflexes integrated in the sacral and lumbar spinal cord might share in the sexual reaction [10].

The behavior of anal sphincters during sexual inter-

Correspondence to: Prof. Ahmed Shafik, Department of Surgery and Experimental Research, Faculty of Medicine, Cairo University, 2 Talaat Harb Street, Cairo 11121, Egypt.
Tel/Fax: +20-2-749-8851
E-mail: shafik@ahmedshafik.com
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course has been poorly addressed in the published literatures. The bulbocavernosus and ischiocavernosus muscles constitute the floor of the perineum (Figure 1). The fibers of the external anal sphincter are continuous with those of the bulbocavernosus muscle [11]. The bulbocavernosus reflex exhibits the response of the cavernosus muscles or the external anal sphincter to stimulation of the glans penis or clitoris [12–14]. The bulbocavernosus reflex is used as a diagnostic tool in the diagnosis of erectile disorders**.** In this study, we prove the hypothesis that cavernosus muscles' contraction affects reflex contraction of the anal sphincters, presumably to guard against flatus or fecal leakage during sexual intercourse. The present study was approved by the Cairo University Faculty of Medicine Review Board and Ethics Committee.

2 Materials and methods

2.1 Subjects

Seventeen healthy subjects volunteered for the present study and gave written informed consent. They were 10 men and 7 women between 28 years and 52 years (mean 38.3 ± 11.6 years). Of the women, 5 were multiparous with normal deliveries and 2 were nulliparous**.** All the studied subjects were sexually active. The men had no erectile or ejaculatory dysfunction and the women were orgasmic. They had no anorectal or gynecologic complaint in the past or at the time of enrollment**.** The results of physical examinations, including gynecologic, proctologic and neurologic examinations, were normal.

2.2 Methods

The response of the external and internal anal sphincters to ischiocavernosus muscle and bulbocavernosus muscles stimulation was studied.

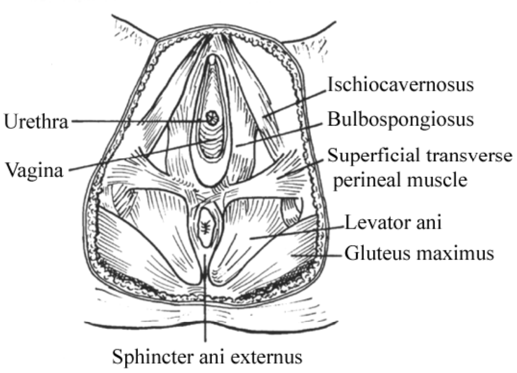

Figure 1. Perineum with bulbocavernosus and ischiocavernosus muscles.

2.2.1 Electromyographic of the cavernosus muscles and anal sphincters

With the subject lying supine, the hip and knee joints flexed and the thighs abducted, an electromyographic (EMG) concentric needle electrode (Type 13L49, Disa, Copenhagen, Denmark), measuring 45 mm in length and 0.65 mm in diameter, was introduced into each of the two cavernosus muscles and the two anal sphincters. For the ischiocavernosus muscle, the ischial ramus with the overlying crus penis or crus clitoris was palpated, and the needle electrode was introduced into the muscle from the medial aspect of the ramus. For the bulbocavernosus muscle**,** the bulb of the penis or the bulb of the vestibule was palpated and the needle electrode inserted into the muscle overlying it. In the women, the bulb of the vestibule lies in the labium majus; the needle electrode was inserted into the middle of the labium majus. A ground electrode was applied to the thigh. For the internal anal sphincters, the needle electrode was introduced 0.5 cm lateral to the anal orifice to a depth of 1.0–1.5 cm. The needle electrode for the external anal sphincters was inserted into the muscle 0.75–1.00 cm lateral to the anal orifice and contralateral to the internal anal sphincter's electrode to a depth of 1.0–1.5 cm.

The correct position of the needle electrodes in the muscles was monitored by the burst of activity heard from the loudspeaker and visualized on the oscilloscopic screen of a standard EMG apparatus (Type MES, Medelec, Woking, UK) as the needle entered the muscle. Fine adjustments of the needle position were made while the EMG response to needle insertion was observed on the chart recorder**.** The normality of the myoelectric activity of the two cavernosus muscles and the two anal sphincters had been verified in all subjects prior to performing the experiment by stimulating each muscle with a needle electrode introduced into the muscle and recording the motor unit action potentials by the recording needle electrode.

The EMG activity recordings were displayed on the screen of the oscilloscope. Films of the potentials were taken on light sensitive paper (Linagraph, type 1895, Kodak, London, UK) from which measurements of the latency of the reflex and motor unit action potentials were made. The EMG signals were, in addition, stored on an FM tape recorder (Type 7758A, Hewlett Packard, Waltham, MA, USA) for further analysis as required.

2.2.2 Cavernosal muscles and anal sphincter anesthetization

To determine whether the anal sphincteric response to cavernosal muscles' stimulation was direct or reflex, each of the two cavernosus muscles in 10 subjects (7 men and 3 women) was anesthetized by injecting 2 mL of 1% lidocaine into the muscle bundles around the relevant electrode. The response of the external and internal anal sphincters to stimulation of the anesthetized cavernosus muscles was recorded 10 min after lidocaine injection, and 2 h later when the anesthetic effect had disappeared. The test was repeated after anesthetizing the anal sphincters, and infiltrating the cavernosus muscles and anal sphincters with saline instead of lidocaine.

2.3 Statistical analysis

To ensure reproducibility of the results, the recordings were repeated at least twice in the individual subject and the mean value was calculated. The results of the study were analyzed statistically using paired *t*-test, and values were given as the mean ± SD. Differences assumed significance at $P < 0.05$.

3 Results

While the two anal sphincters exhibited resting EMG activity, the two cavernosus muscles did not. On stimulation of the two cavernosus muscles with a needle electrode, the bulbocavernosus muscle contracted with a mean amplitude of motor unit action potentials of (302.4 ± 49.6) V (ranging from 204 to 408 V) (Figure 2A) and the ischiocavernosus muscle of (254.8 ± 50.7) V (ranging from 144 to 366 V) (Figure 2B). The EMG of the external anal sphincters recorded a mean resting amplitude of (132.6 ± 28.4) V (ranging from 98 to 196 V) and a squeezing activity of (708.6 ± 67.8) V (ranging from 520 to 840 V) (Figure 2C). The internal anal sphincters resting EMG recorded basal activity waves superimposed on slow waves. The mean amplitude of the basal activity waves was (24.4 ± 3.2) V (ranging from 20 to 32 V) and of the slow waves (212.8 ± 40.5) V (ranging from 140 to 380 V) (Figure 2D).

Upon stimulation of each of the cavernosus muscles by a train of five square pulses of 1 ms duration and a mean threshold of (52.4 ± 10.6) mA (ranging from 42 to 64 mA) both the external and internal anal sphincters recorded increased EMG activity which could be easily palpated at the anal orifice as sphincteric contractions. The mean amplitude for the external anal sphincters was (558.6 ± 46.8) V (ranging from 412 to 660 V) and for the internal anal sphincters was (386.4 ± 51.7) V (ranging from 260 to 488 V) (Figure 3). Repeated and successive cavernosus muscles' stimulation evoked the response of the anal sphincters without fatigue. The response was weaker in the women than in the men although the difference was insignificant ($P > 0.05$). There was no apparent difference between the multiparous and the nulliparous women.

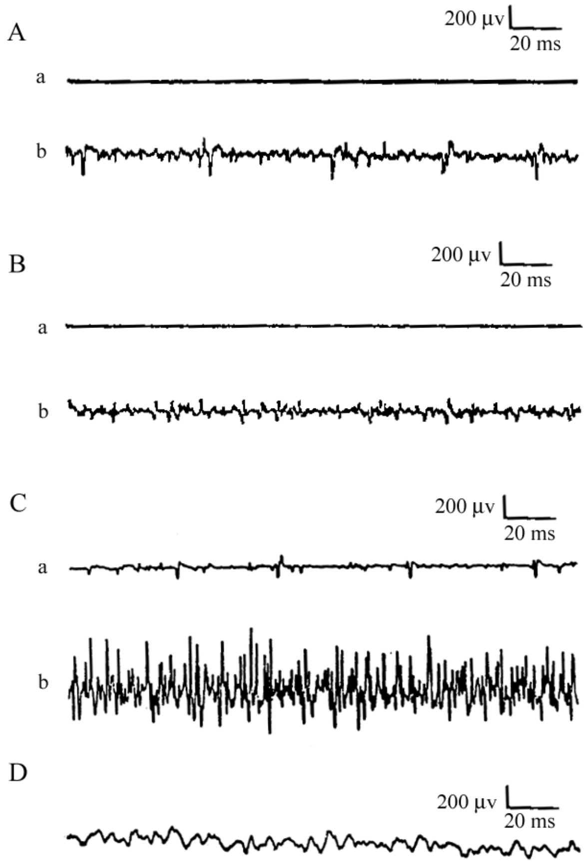

Figure 2. (A): Electromyographic (EMG) activity of the bulbocavernosus muscle. (a) at rest: no activity; (b) on stimulation of the muscle. (B): EMG activity of the ischiocavernosus muscle. (a) at rest: no activity; (b) on stimulation of the muscle. (C): EMG activity of the external anal sphincter. (a) at rest showing basal activity; (b) on voluntary squeezing. (D): EMG activity of the internal anal sphincter showing basal activity waves superimposed on slow waves.

Stimulation of the anesthetized cavernosus muscles did not evoke anal sphincters' contraction, nor did cavernosus muscles' stimulation achieve contraction of the anesthetized anal sphincters. The responses returned after 2 h from lidocaine administration when the anesthetic effect had disappeared. On the other hand, stimulation of the cavernosus muscles after saline infiltration did affect response of the anal sphincters, and vice versa the cavernosus muscles responded to stimulation of the saline-infiltrated anal sphincters.

The latency of the response was measured from the stimulus to the first deflection of the muscle action potential complex recorded from the muscle (Figure 3). On stimulation by a train of five square pulses of 1 ms duration, the threshold varied from 42 mA to 64 mA, with a mean of (52.4 ± 10.6) mA, and the latency at threshold varied from 28 to 39 ms (mean [33.8 ± 4.4] ms) for the external anal sphincters and from 22 to 34 ms (mean [27.4 ± 3.2] ms) for the internal anal sphincters.

The aforementioned results were reproducible in the individual subjects.

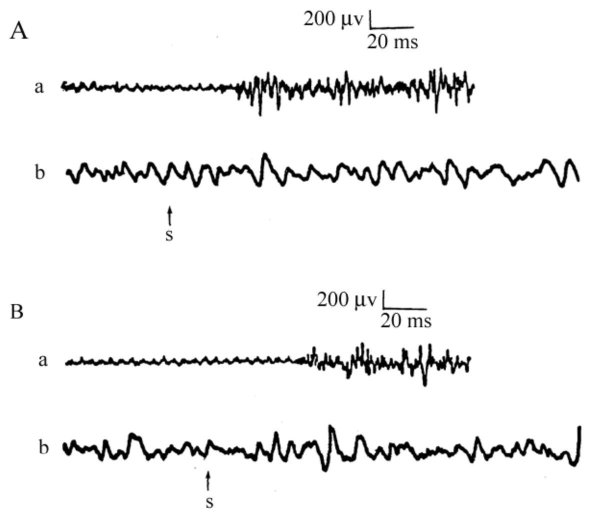

Figure 3. (A): Electromyographic (EMG) recording of the cavernoso-anal reflex. Stimulation of the bulbocavernosus muscle resulted in external (a) and internal (b) anal sphincter contraction. Latency was 28.2 ms for external anal sphincters and 23.4 ms for internal anal sphincters. S: stimulation. (B): EMG recording of the cavernoso-anal reflex. Stimulation of the ischiocavernosus muscle resulted in external (a) and internal (b) anal sphincter contraction. Latency was 37.3 ms for external anal sphincters and 22.1 ms for internal anal sphincters. S: stimulation.

4 Discussion

The cavernosus muscles contract repeatedly during the sexual intercourse [14, 15]. They presumably assist in penile or clitoral erection by compression of both the deep dorsal vein of the penis or clitoris and the cavernosal tissue [8]. Furthermore**,** because of their insertion into the body of the penis or clitoris, the cavernosus muscles when contracting appear to share in the mechanism of penile or clitoral elevation during erection [5–7].

4.1 The cavernoso-anal reflex

Anal sphincteric contraction following cavernosal muscles' contraction postulates a hitherto unrecognized reflex relationship between the two actions. This relationship was reproducible and its reflex nature was evidenced by non-response of the anal sphincters to stimulation of the anesthetized two assumed arms of the reflex arc**:** the cavernosal muscles and anal sphincters. We call this reflex relation the "cavernoso-anal reflex". The possible argument that lidocaine injection into the muscle might block the muscle activity can be ruled out because lidocaine blocks the C and A α-fibers, which are the sensory fibers responsible for pain and reflex activity [16, 17]. The weaker response in women than men or in multiparous than nulliparous women could be related to sphincteric changes resulting from repeated deliveries.

4.2 Role of cavernoso-anal reflex during sexual intercourse

Cavernosus muscles' contraction during coitus presumably leads to contraction of the anal sphincters. The exact role of anal sphincteric contraction during coitus is not known. It might be assumed that anal sphincteric contraction is functioning to prevent leak of flatus or feces during sexual intercourse. Moreover, it seems that the contraction of the cavernosus muscles indirectly effects urethral sphincter contraction. Previous studies demonstrate that anal sphincteric contraction evokes the ano-urethral reflex with a resulting external urethral sphincter contraction [18]. Therefore, cavernosal muscles' contraction induces contraction of both the anal and urethral sphincters. It is very likely that the sphincteric contraction, anal and urethral, plays an essential role during orgasm. During orgasm, augmented rhythmic contractions of the cavernosus muscles help the emission of the forceful ejaculatory spurt [15]. The reflex urethral sphincter contraction in men acts not only to prevent retrograde ejaculation but also to milk the semen down the prostate into the penile urethra. Furthermore, at orgasm, it prevents urine leaking from the vesical neck and mixing with the ejaculate.

The contraction of the anal sphincters on cavernosal muscles' contraction at orgasm seems to offer a protective physiologic mechanism against fecal or flatus leakage. As excitement increases, certain motor responses become more predictable and less voluntary, especially pelvic thrusting and contraction of the rectus abdominis muscle [15]. During orgasm, spasm of these muscles is maximal with a resulting increase of the intra-abdominal pressure and risk of fecal and gas leakage [15]. Reflex anal sphincteric contraction under these circumstances would provide a protective physiologic mechanism against fecal and gas leakage.

4.3 Diagnostic role of the cavernoso-anal reflex

The internal anal sphincter's tone is controlled by sympathetic (hypogastric) and sacral parasympathetic pathways, whereas the external anal sphincters and cavernosus muscles are controlled by somatic innervation [19]. The cavernoso-anal reflex might prove of the diagnostic significance in sexual disorders. Prolonged latency of the reflex or change in the amplitude of motor unit action potentials (MUAP) presumably signify a defect in the reflex pathway, which could represent muscle or nerve damage from a disease of the spinal cord, the spinal nerve roots, or the peripheral nerves. The nerve involvement could be in the afferent or efferent limbs of the reflex arc or in the spinal cord. The measuring of the latency and MUAP could, therefore, be an objective and accurate means of demonstrating the intactness of this pathway. The reflex might, therefore, be incorporated as an investigative tool in the study of patients with disorders of the sexual act; this, however, requires further investigation.

In terms of diagnostic efficacy, the cavernoso-anal reflex is believed to be more constant than the bulbocavernosus reflex, as the former was reproducible in the individual subject. The reported constancy of the bulbocavernosus reflex in normal subjects was questioned by investigators who found it inconstant and of variable latencies in the same subject [20]. The bulbocavernosus reflex, however, serves currently in determining whether an erectile dysfunction is of neurogenic origin [13, 14]. Further studies of the cavernoso-anal reflex might prove its diagnostic significance in such conditions.

In conclusion, cavernosus muscles' contraction is suggested to evoke anal sphincteric contraction. This effect seems to be a reflex and mediated through the cavernoso-anal reflex. Anal sphincteric contraction upon cavernosus muscles' contraction during sexual intercourse presumably acts to close the anal canal to prevent flatus or fecal leak during coitus. Further studies might prove the reflex to be of diagnostic significance in sexual disorders.

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