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ABSTRACT

Introduction and Objectives: A comprehensive description of the neural circuitry controlling ejaculation is missing. We aimed to increase understanding of such circuitry by integrating results obtained upon electrical stimulation (ES) of nerves involved in the control of the ejaculatory process, namely the dorsal nerve of the penis (DNP) containing sensory afferences from the penis and urethra and the intermesenteric nerves (IMN), which contains most of the afferent and efferent fibers running in the hypogastric nerve (HN) to and from the pelvic viscera, including sexual accessory glands.

Methods: Bulbospongiosus muscle electromyogram were recorded in isoflurane-anesthetized Wistar rats. Rats from different groups were submitted to electrical stimulations (ES, 1 ms, 6 V, 60 Hz for 30 s) of the intact IMN (n=20), of the proximal or distal stump of the cut IMN (n=10 and 10 respectively), or of the intact IMN after T8 spinalization (n=10). Same recordings were performed upon ES of the intact HN (n=10), ES of the DNP were performed in control (n=4) and T8 spinalized rats (n=8).

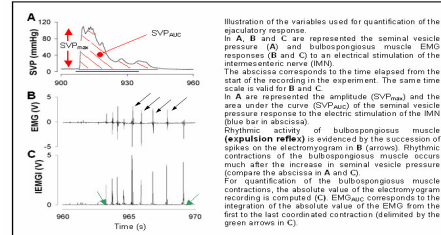
Results: ES of the IMN was often followed by rhythmic activity of the bulbospongiosus muscle similar to that occurring during the expulsion phase of ejaculation, with or without emission of a seminal plug (corresponding to plug expulsion - PE and expulsion reflex - ER). PE and ER occurred 29/100 and 14/100 ES respectively upon ES of the IMN. In comparison, the occurrence of PE and ER was decreased upon ES of the HN (6/50 and 4/50 ES respectively). The occurrence of PE and ER was dramatically reduced upon ES of the distal stump of the cut IMN (2/45 and 2/45 ES respectively). In contrast, the occurrence of PE and ER was decreased (2/25) and increased (12/25) respectively upon ES of the proximal stump of the cut IMN. Spinalization at the T8 level abolished the occurrence of both ER and PE upon ES of the IMN. ER persisted upon ES of the DNP in T8 spinalized rats, but there was no PE.

Conclusions: Upon ES of the IMN, recruitment of both afferences and efferences were necessary to achieve complete ejaculation, but ES of afferences were sufficient to induce expulsion reflex. These results support that visceral afferents from the seminal tract are activated during emission of sperm and participate to the triggering of sperm expulsion. Results obtained after spinalization also suggests that emission is exclusively controlled by a supraspinal reflex, whereas expulsion is controlled by a supraspinal and a spinal reflex.

METHODS

- Intact or acutely T8 spinalized isoflurane-anesthetized Wistar rats
- Electrostimulation of peripheral nerves: ES IMN - HN (1 ms, 6 V, 60 Hz for 30 s)
- Recordings :

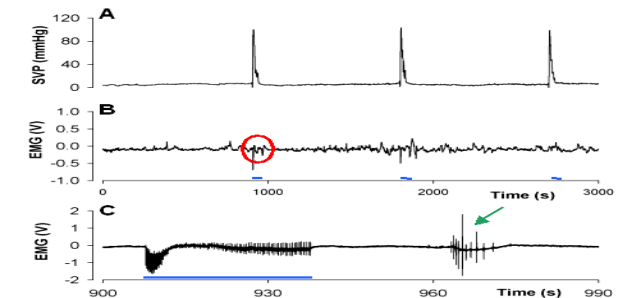
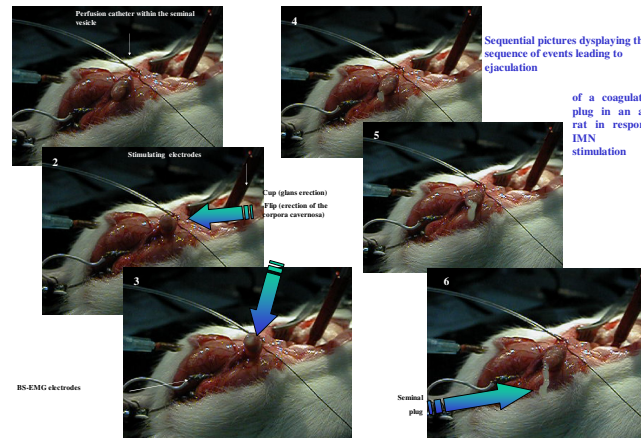
Bulbospongiosus EMG
Seminal Vesicle Pressure (SVP)



After standard surgical preparation, the intermesenteric nerves (IMN) were exposed with the aid of a dissecting microscope and mounted on bipolar platinum electrodes connected to an electrical stimulator (AMS 2100, Phymep, France).

- Five ES of the IMN or HN were performed every 15 min.
- SVP was recorded with a catheter inserted in one seminal vesicle tail and connected to a pressure transducer. The catheter was connected to a syringe pump with a t-tube, allowing simultaneous recording of SVP and perfusion of the seminal vesicle with saline to avoid clotting at the tip of the catheter.
- Electromyographic recording of the bulbospongiosus (BS EMG) muscle was performed by placing two thin bared silver electrodes 1-2 mm apart into the muscle. Recorded signal was amplified (DP-301, Warner Instrument Corp., Phymep; gain, 10000; Low pass, 10 KHz; High pass, 10 Hz) before being digitized.

RESULTS



Quantification of the SVP increase

SVP increase (mm Hg)	IMN				HN
	Control (n=20)	Proximal stump (n=10)	Distal stump (n=10)	T8 (n=10)	
	104 ± 1	24 ± 4	90 ± 10	99 ± 14	109 ± 4

Electrostimulation of intact IMN or HN in normal or T8 spinalized rats. In 2 groups, IMN were cut and proximal or distal stump were electrically stimulated.

Quantification of the SVP increase

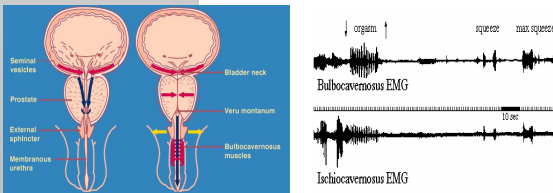
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BACKGROUND

Ejaculation consists in the succession of distinct physiological events

- Closure of the bladder neck, to prevent flow of semen backward in the bladder from the prostatic urethra, precedes and goes with
- The emission phase (secretion by seminal vesicles, prostate and ampullary vas deferentia) contents into the prostatic urethra of the different sperm components.
- Forceful expulsion of sperm to the urethral meatus is then caused by rhythmic contractions of pelvic and perineal striated muscles, with a primary role for the bulbospongiosus muscle.



Emission :

- seminal vesicle (50-80%)
- prostate (15-30%)
- Cowper's gland
- testis (<0.1%)

Expulsion :

- Bulbospongiosus and ischiocavernosus EMG in human male

Gorenberg et al. Br J Urol, 1990, 65: 395-402.

Mans and Lumbak-Mans. Male reproductive function and semen. Berlin-Heidelberg-New York: Springer-Verlag, 1981, pp 171-93.

OBJECTIVES

To increase the understanding of peripheral neural circuitry controlling ejaculation by integrating results obtained upon electrical stimulation (ES) of nerves involved in the control of the ejaculatory process, namely the dorsal nerve of the penis (DNP) containing sensory afferences from the penis and urethra and the intermesenteric nerves (IMN), which contains most of the afferent and efferent fibers running in the hypogastric nerve (HN) to and from the pelvic viscera, including sexual accessory glands, experiments were performed in intact and spinalized rats.

DISCUSSION

- The ability of ES of the IMN/HN pathway to induce ejaculation in anesthetized rats has never been reported so far, although the role of the IMN/HN pathway in the control of bladder neck closure, contraction of seminal vesicles, and seminal fluid secretion has been demonstrated in dogs and rats (2; 3; 4).
- The IMN/HN pathway is a preferential route for efferent sympathetic fibers issued from the thoracolumbar levels of the spinal cord destined to the pelvis including the seminal tract. It is also a preferential route for the corresponding viscerofugal afferent fibers destined to the thoracolumbar levels of the spinal cord (5; 6; 7).

CONCLUSION

We have demonstrated that ejaculation could be induced in anesthetized rats by ES of the IMN. The results gained from this model supports that afferences from the seminal tract are activated during the emission phase and participate to the triggering of the expulsion phase. It also suggests that emission is controlled exclusively by a supraspinal reflex. In contrast, expulsion appears to be controlled by two different reflexes, handled respectively at the spinal and supraspinal level.

Hypothetical neural circuitry controlling ejaculation.

Sensory input from the glans are conveyed through afferent fibers in the dorsal nerve of the penis (DNP) and further in the sensory branch of the pudendal nerve (PND). They join the spinal cord through the dorsal horn at the lumbosacral level (L6-S1, [1]). Afferent signals from the glans are then processed and conveyed to the lumbar level where they reach the spinal generator of ejaculation (SGE). Beyond a definite threshold of stimulation, the SGE sends signals to the supraspinal center of ejaculation (SCE), which in turn triggers the emission phase by activating sympathetic efferences [2] originating from the thoracolumbar level to the sexual accessory glands (SAG). These sympathetic efferences course in the intermesenteric nerves (IMN) after crossing the coeliac superior mesenteric ganglion (CSMG) and further in the hypogastric nerves (HN) after crossing the inferior mesenteric ganglion (IMG). Sympathetic fibers issued from the paravertebral sympathetic chain and joining the IMN and HN are not represented for sake of clarity. Somehow, emission of sperm into the prostatic urethra induces an afferent volley from the SAG or bladder neck (BN) [4] which joins the thoracolumbar sympathetic nuclei through afferent fibers running in the IMN and HN, and then to the SSGE. The function of this afferent volley is to inform the SSGE that the emission did take place, and that the expulsion phase should proceed. Then, the SSGE may send a seminal signal to the SGE [3], which commands the expulsion phase [5] by activating the motoneurons of the bulbospongiosus muscle located in the dorsomedial nucleus (DM, [7]), whose axons run in the motor branch of the pudendal nerve (PMB). This schematic circuitry does not include spinal relays. We hypothesize that in physiological conditions, the afferent signal from the pelvic viscera reinforces the coordination between the emission and expulsion phases. Nevertheless, afferent signals from the pelvic anatomical structures involved in the ejaculation process do not seem necessary for the expulsion phase to occur, and likely constitute a safety factor.

