CONTRACTILE ACTIVITY OF THE PROSTATE AT EJACULATION: AN ELECTROPHYSIOLOGIC STUDY

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ABSTRACT

Objectives. To investigate the hypothesis that the prostate contracts at ejaculation to push its secretions into the urethra. Although it has been mentioned that the prostate contracts at ejaculation, a report of this finding could not be traced in published studies.

Methods. The electromyographic activity of 8 canine prostates was recorded by applying an electrode to the prostate. The prostatic urethral pressure was simultaneously measured by means of a manometric catheter. The prostatic electromyographic and urethral pressures were recorded at rest and on ejaculation by penile electrovibration.

Results. The prostatic slow waves (SWs) and action potentials (APs), as well as the urethral pressure at rest, showed a significant increase during the ejaculatory bouts ($P < 0.05$ and $P < 0.05$, respectively). The SWs, APs, and pressure increase occurred simultaneously with each bout of ejaculatory spurt, which occurred at mean intervals of $1.1 \pm 0.02$ seconds and a number of $4.6 \pm 1.2$ bouts.

Conclusions. The electric waves discharged from the prostate at rest seemed to produce prostatic contractions, which cause prostatic urethral pressure increases. At ejaculation, the intermittent increase of the wave variables and urethral pressure coincided with the ejaculatory spurts, apparently denoting intermittent prostatic smooth muscle contractions. These contractions seem to squeeze the prostatic secretions into the prostatic urethra. UROLOGY 67: 793–796, 2006. © 2006 Elsevier Inc.

The prostatic gland shares in the formation of the seminal plasma by its secretions. It consists of alveoli lined by tall columnar secretory epithelial cells and drains by ducts into the posterior urethra. The alveoli and ducts are embedded within a stroma of fibromuscular tissue. Of the five prostatic zones described by McNeal, the “anterior fibromuscular stroma” is a continuous sheet of fibrous tissue and smooth muscle that surrounds the urethra proximally at the bladder neck, where it merges with the internal sphincter and detrusor muscle. Although the other prostatic zones contain smooth muscle, the anterior fibromuscular stroma comprises up to one third of the total bulk of the prostate and is entirely lacking the glandular elements. The main component of the “preprostatic tissue zone” is smooth muscle that surrounds the preprostatic urethra.

The major contribution to the seminal plasma volume derives from the seminal vesicles (3 mL), prostate (1.5 to 2 mL), Cowper's gland (0.5 mL), and Littre glands (0.1 to 0.2 mL). During ejaculation, the secretions of these glands are released in a sequential manner. Normal antegrade ejaculation involved two basic mechanisms: emission and ejection. Emission acts to bring the semen to the posterior urethra through the glans-vasal reflex, and ejection propels it to the exterior by the urethromuscular and urethrocavernosus reflexes. In emission, secretions from the seminal vesicles and prostate, as well as sperm from the vas deferens and ampulla of the vas, are deposited into the posterior urethra. Ejection involves closure of the bladder neck, as well as external urethral sphincter relaxation and cavernous muscle contractions.

Although investigators have mentioned that the prostate contracts at ejaculation, this finding has been poorly addressed in published studies. We investigated the hypothesis that the prostate contrac-
tracts at ejaculation to push its secretions to the urethra, thus sharing in ejaculate formation.

**MATERIAL AND METHODS**

Eight male mongrel dogs with a mean weight of 17.3 ± 2.8 kg (range 13 to 21) were studied. They had normal prostates, testicles, and spermatic cords, as shown by clinical and ultrasound examination. They were housed in cages and treated in compliance with the Guide for the Care and Use of Laboratory Animals. The Review Board and Ethics Committee of Cairo University Faculty of Medicine approved the study protocol.

**ELECTROMYOGRAPHIC STUDIES**

The dogs were premedicated with acepromazine (0.15 mg/kg body weight) subcutaneously. They were anesthetized with intravenous sodium pentobarbital (35 mg/kg body weight) with a bolus injection of 20 to 25 mg/hr to maintain adequate anesthesia with spontaneous respiration.

The abdomen was opened through a subumbilical incision and the prostate exposed. A monopolar silver-silver chloride electrode (Smith Kline Beckman, Los Angeles, Calif) was sutured to middle of the dorsal aspect of prostate between the prostate and rectum. The electrode had a diameter of 0.8 mm and was covered with an insulating vinyl sheath, sparing its tip. The insulated wire lead was attached to the pin of the metal cannula and connected to a Brush Mark 200 rectilinear pen recorder. In each dog, electric activity was recorded from the electrode for a period of 30 minutes.

**MANOMETRIC STUDIES**

The mechanical activity of the prostate was simultaneously recorded with its electrical activity. This was done by measuring the prostatic urethral pressure using a 4F catheter with two lateral 0.5-mm side ports and a closed distal end with a metallic ring for fluoroscopic control. The catheter was placed in the prostatic urethra and infused with 37°C sterile saline at a rate of 2 mL/min. The catheter was connected to a strain gauge pressure transducer (Statham, 2306, Oxnard, Calif).

While the animals were under anesthesia, ejaculation was accomplished by penile electrovibration.10 Prostatic electromyographic activity and prostatic urethral pressure were recorded at rest and on penile electrovibration. To ensure reproducibility of the results, the recordings in the individual animal were repeated at least twice, and the mean value was calculated.

**STATISTICAL ANALYSIS**

The results were analyzed statistically using Student’s *t* test. The values are given as the mean ± SD. Significance was ascribed to *P* < 0.05.

**RESULTS**

The study was completed with no adverse side effects, and all animals were evaluated. Monophasic slow waves (SWs) were recorded from the electrode applied to the prostate. The wave had a large negative deflection that was constant in all recordings from the same site. It exhibited, in each animal, the same frequency, amplitude, and conduction velocity; these variables were constant in each animal during the recording period. The wave frequency registered a mean of 4.1 ± 1.3 cycles/min, amplitude of 0.72 ± 0.16 mV, and conduction velocity of 4.4 ± 1.3 cm/s (Fig. 1 and Table 1).

Bursts of fast activity spikes or action potentials (APs) followed, or were superimposed on, the SWs in the form of negative deflections (Fig. 1). They occurred randomly, did not follow each SW, and were inconsistent in each individual animal. Being inconsistent, their frequency, amplitude, and conduction velocity could not be calculated.

The resting pressure in the prostatic urethra was recorded at a mean of 60.2 ± 7.8 cm H₂O (range 51 to 68). It did not exhibit significant changes during the recording of the SWs (Fig. 2). Simultaneously with the occurrence of APs, it showed, however, a significant increase, recording a mean of 83.3 ± 6.3 cm H₂O (range 73 to 94, Fig. 2).

Ejaculation in all animals was achieved by penile electrovibration. At ejaculation, the frequency, amplitude, and conduction velocity of SWs and APs increased significantly (*P* < 0.05, *P* < 0.05, and *P* < 0.05, respectively). The mean frequency was 10.6 ± 2.1 cycles/min, mean amplitude 1.3 ± 0.3 mV, and mean conduction velocity of 9.2 ± 1.7 cm/s (Fig. 3 and Table 1). The wave variable increase remained for 0.7 to 1.1 s (mean 0.87 ± 0.02) and then returned to the resting stage (Fig. 4). It occurred simultaneously with each bout of ejaculatory spurt at intervals of 0.8 to 1.4 s (mean 1.1 ± 0.02). Each ejaculatory spurt was associated with an increase in prostatic electromyographic activity. The number of bouts of increased electric waves varied from 3 to 6 bouts (mean 4.6 ± 1.2). After completion of ejaculation, the prostatic electric activity returned to the resting stage.

The prostatic urethral pressure exhibited a significant increase (*P* < 0.05) simultaneously with the ejaculatory bouts, recording a mean of 104.2 ± 9.6 cm H₂O (range 92 to 118, Fig. 5). Between bouts, the pressure returned to the resting stage. The intermittent prostatic urethral pressure rise continued until ejaculation was complete, at which point the pressure returned to the resting stage. Urethral pressure elevation was concordant with the APs, which showed a significant increase at the ejaculatory bouts.

It was noted that in all animals, prostatic urethral pressure elevation and an increase in APs occurred, not only simultaneously with each ejaculatory
bout, but that the number of urethral pressure and AP elevations coincided with those of the ejaculatory spurts.

**COMMENT**

Prostatic contractions have been suggested to occur to squeeze out the prostatic secretions. This concept has not yet been verified. The results of the current study have demonstrated that the prostate in its resting stage discharges electric waves in the form of SWs and APs. The APs represent fast activity spikes that follow, or are superimposed on, the SWs. The significant increase in the prostatic urethral pressure simultaneously with APs seems to denote that APs have mechanical action that may be represented by prostatic contractions.

The prostate contains smooth muscle fibers, the contraction of which appears to be responsible for the urethral pressure increase associated with APs. The infrequent and random occurrence of APs at rest points to an irregular or nonrhythmic contraction of the prostatic muscle fibers. The function of this prostatic contractile activity in association with APs and occurring at rest is hitherto unknown. It is likely that the resting activity acts to evacuate the prostatic acini of their secretion, thus preventing stagnation and resultant infection. Alternatively, this occasional contractile activity may function to increase prostatic vascularity. Recently, Keener *et al.* reported an increase in prostatic blood flow after ejaculation as demonstrated by transrectal ultrasound examination. This increase remained elevated for at least 24 hours.

Our study has shown that the number of bouts of urethral pressure elevation and increases in APs coincide with the number of ejaculatory spurts. This finding apparently indicates the existence of a relationship between the two conditions. At ejaculation, the intermittent and significant increase in electric wave variables, associated with rise in urethral pressure, presumably denotes intermittent contractions of the prostatic smooth muscle. These contractions are thought to squeeze the prostatic secretions into the prostatic urethra because they

### TABLE I. Frequency, amplitude, and conduction velocity of prostate recorded at rest and during ejaculatory bout

<table>
<thead>
<tr>
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<th>Frequency (cpm)</th>
<th>Amplitude (mV)</th>
<th>Conduction Velocity (cm/s)</th>
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<tbody>
<tr>
<td>At rest</td>
<td>4.1 ± 1.3 (3.1-5.3)</td>
<td>0.72 ± 0.16 (0.6-0.9)</td>
<td>4.4 ± 1.3 (3.6-5.8)</td>
</tr>
<tr>
<td>At ejaculation</td>
<td>10.6 ± 2.1* (7.5-13.4)</td>
<td>1.3 ± 0.3* (1.1-1.8)</td>
<td>9.2 ± 1.7* (6.7-12.6)</td>
</tr>
</tbody>
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* P < 0.05; P values at ejaculation were compared with those at rest.

**FIGURE 2.** Simultaneous recording at rest of prostatic electric activity and prostatic urethral pressure. Urethral pressure (lower tracing) recorded increase only with occurrence of action potentials (upper tracing: arrow points to slow waves, dotted arrow to action potentials).

**FIGURE 3.** Electroprostatogram at ejaculation showing increase in frequency, amplitude, and conduction velocity of slow waves, as well as increase in action potentials.

**FIGURE 4.** Electroprostatogram in resting stage after ejaculation showing regular slow waves and random action potentials.

**FIGURE 5.** Simultaneous recording at ejaculation of prostatic electric activity (upper tracing) and prostatic urethral pressure (lower tracing).
occur simultaneously with each spurt of semen ejaculation.

The mechanism of prostatic smooth muscle contraction at ejaculation needs to be discussed. During the sexual act, and close to the point of orgasm, an increase in sympathetic stimulation occurs, which seems to be responsible for effecting the prostatic smooth muscle contractions. Experimental studies have shown that stimulation of the thoracolumbar segments of spinal cord, with resulting release of sympathetic outflow, causes passage of prostatic secretions to the urethra. The propelling of semen through the urethra is provided by the somatic pudendal efferent nerve in the striated muscles of the pelvic floor. A concurrent sympathetic stimulation closes the bladder neck and effects contractions of the prostate, ampulla of vas deferens, and seminal vesicles to propel semen to the prostatic urethra. Under somatic control of the pudendal nerve, the semen is finally expelled to the anterior urethra through an opening of the urogenital diaphragm, aided by rhythmic contractions of the bulbocavernosus/ischio cavernosus and pelvic floor muscles. Increased pelvic floor muscle activity, especially puborectalis muscle activity, may share in the expression of prostatic secretions. It also seems that the nerve transmitter nitric oxide plays a role in regulating the smooth muscle contractions of prostate, vas deferens, and seminal vesicles.

**CONCLUSIONS**

Electric waves discharged from the prostate at rest seem to produce prostatic contractions that appear to be responsible for increases in the prostatic urethral pressure. At ejaculation, the intermittent and significant increase in wave variables and urethral pressure coincided with the ejaculatory spurts and apparently denotes intermittent prostatic smooth muscle contractions. These prostatic contractions seem to squeeze the prostatic secretions into the prostatic urethra.