Electric Activity of the Testicular Tunica Albuginea During Ejaculation: A Canine Study

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We have shown in previous studies that electric waves at rest could be recorded from the testicle and originate from the tunica albuginea (TA) and not from the testicular tissue. In the current study, we investigated the hypothesis that the electric activity of the TA increases during ejaculation. Three electrodes were sutured to the TAs of 11 anesthetized male dogs. The slow waves were recorded at rest and on inducing ejaculation by an ejaculator applied to the glans penis. Basal electric waves were recorded from the testicle. Each wave consisted of a negative followed by a positive deflection with a mean frequency of 6.2 ± 1.3 cycles/min, an amplitude of 0.59 ± 0.06 mV, and a conduction velocity of 5.2 ± 0.8 cm/sec. These wave variables showed a significant intermittent increase ($P < 0.05$) at intervals of 0.6–1.0 secs and occurred simultaneously with the bouts of ejaculation. The increase remained for 0.8–1.2 secs at each ejaculation bout. The number of bouts of increased electric waves varied from 3 to 5. Apparently, the TA is not an inert covering to the testicle, but it seems to have a functional activity. Recording resting electric waves of the TA presumably denotes that the TA possesses a resting tone that appears to support the testicular tissue. During ejaculation, the increased electric activity of the TA, which coincides with semen spurt episodes, presumably denotes TA contraction. The intermittent TA contractions seem to assist in massaging the testicular secretions to the epididymis and the vas deferens and augment testicular circulation. The effect of pathologic conditions of the TA on ejaculation needs to be studied. Exp Biol Med 230:569–572, 2005

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Introduction

The testicular tunica albuginea (TA) consists of collagenous tissue containing smooth muscle cells (SMCs; Ref. 1) that seem to induce the contractile activity of the TA. Contraction of the TA in humans and other species was induced by electrical stimulation of the TA and the administration of specific autonomic drugs (2–4). The TA tone or contractions may affect the testicular blood flow as the testicular artery traverses the TA at an oblique angle (5).

Testicular and parenchymal volumes decreased significantly with age, while the TA volume remained unchanged (6). Scanty quantitative changes in the testicular connective tissue occurred with age, while the age-related changes in the testicular volume are principally restricted to the seminiferous tubules (6). Previous studies reported that the testicular capsule seems to be required for normal sperm transport from the seminiferous tubules into the rete testis (7). Testicular capsulotomy resulted in germ cell degeneration and reduction in endogenous luteinizing hormone (8, 9).

By means of electrodes applied either transcutaneously or directly to the TA, we have, in previous studies, recorded electric waves from the testicle (10). Each wave consisted of a negative followed by a positive deflection. The waves registered by transcutaneous recording were identical to those registered from the same individual by electrodes applied directly to the testicle (10).

A recent study revealed that these electric waves were recorded from the TA and not from the testicular tissue (11). The waves seem to be generated by the interstitial Cajal cells and delivered to the SMCs, which initiate contractile activity. The recording of electric waves at rest from the TA apparently denotes that the TA possesses a resting tone. We hypothesized that the electric activity of the TA increases during ejaculation, with a resulting increase in the

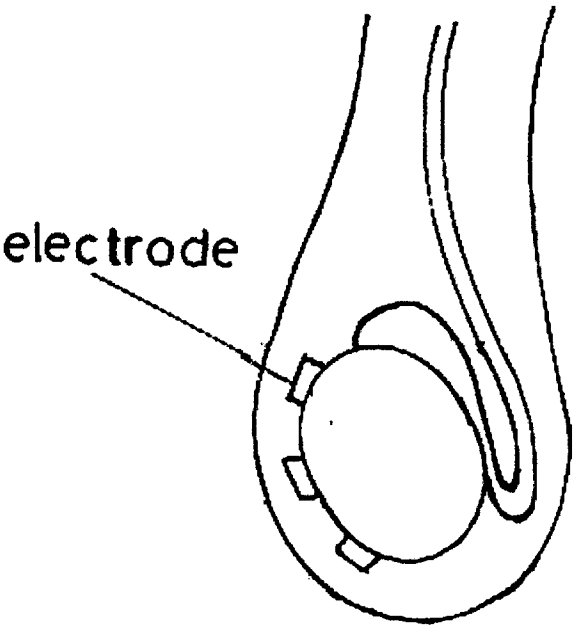

Figure 1. Electrodes applied to the tunica albuginea (TA).

contractile activity of the TA that might assist in squeezing the secretions from the testicle into the vas deferens.

Materials and Methods

Eleven male mongrel dogs with a mean weight of 17.4 ± 2.5 SD kg (range: 14–20) were studied. Their testicles and spermatic cords were normal as shown on clinical and sonographic examinations. They were hosted in cages and treated in compliance with *The Guide for Care and Use of Laboratory Animals.*

Each animal was premedicated with a subcutaneous injection of acepromazine (0.15 mg/kg), and each was anesthetized with sodium pentobarbital (35 mg/kg) given as a bolus injection at 20–25 mg/hr to maintain adequate anesthesia with spontaneous respiration. All dogs were intubated to assist ventilation. With the animals lying on their backs, a 2–3 cm longitudinal scrotal incision was created on the right testicles of 6 dogs. The same incision was created on the left testicles of the other 5 dogs.

On each of the animals, the tunica vaginalis was opened, and three electrodes were sutured to the TA of the testicle using 5/0 vicryl sutures. The first electrode was applied to the upper third of the testicle, the second was applied to the middle third, and the third was applied to the lower third (Fig. 1). The electrodes were monopolar and made of silver-silver chloride. They had diameters of 0.8 mm and were covered with an insulating vinyl sheath sparing their tip (Smith Kline Beckman, Los Angeles, CA). A metal cannula containing the 3-pin socket to which the electrodes were attached was sutured to the anterior abdominal wall, and a strain gauge respiratory transducer was fixed to the thoracic wall. The scrotal wound was closed, and the animal was woken from the anesthetic.

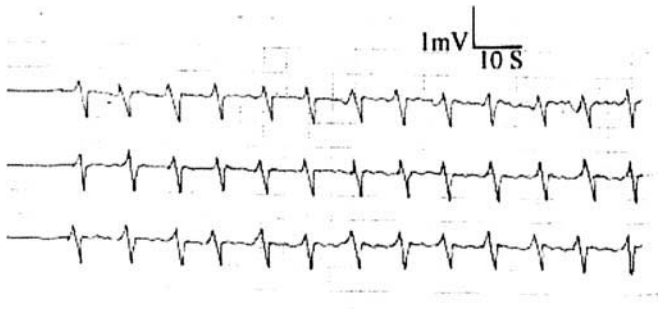

Figure 2. Electric waves recorded at rest from the electrodes applied to the TA.

To allow for wound healing, recordings were started 2 weeks after the operation. Insulated wire leads were attached to the pins in the cannula and connected to a Brush Mark 200 rectilinear pen recorder (Smith Kline Beckman). The electric activity, comprising the amplitude, frequency, and conduction velocity of the waves, was recorded from the three electrodes in each dog at rest and during ejaculation, which was induced by means of electrovibration (12).

To ensure reproducibility of the results, the recordings in each dog were repeated at least twice and the mean value was calculated. The results were analyzed statistically using the Student's t test, and values were given as the means ± SD. Differences assumed significance at $P < 0.05$.

Results

The tests were performed and completed in all of the animals without complications.

Electric Activity of the Testicle at Rest. Electric waves were recorded from the three electrodes applied to the TA of all the studied animals. Each wave consisted of a negative followed by a positive deflection, and this configuration was constant in all the recordings obtained from the same animal. The waves had a mean frequency of 6.2 ± 1.3 cycles/min, an amplitude of 0.59 ± 0.06 mV, and a conduction velocity of 5.2 ± 0.8 cm/sec (Table 1 and Fig. 2). The waves recorded from the three electrodes of the same animal had similar frequencies, amplitudes, and conduction velocities. However, these variables differed from one animal to the other. Abnormal waves were not encountered in any of the animals studied.

Electric Activity of the Testicle During Ejaculation. We succeeded in effecting ejaculation in all the animals. The wave frequencies, amplitudes, and conduction velocities during ejaculation increased significantly ($P < 0.05$, $P < 0.05$, and $P < 0.05$, respectively). The frequency recorded a mean of 12.6 ± 2.7 cycles/min, the amplitude recorded a mean of 1.3 ± 0.2 mV, and the conduction velocity recorded a mean of 8.3 ± 1.4 cm/sec (Table1 and Fig. 3). The increase of the wave variables remained for 0.8–1.2 secs (mean: 0.92 ± 0.02) and then returned to the resting stage. It occurred simultaneously with the bouts of

Table 1. The Frequency, Amplitude, and Conduction Velocity of the TA Electric Waves of 11 Dogs at Rest and During Ejaculation[a]

	Electric waves					
	Frequency (cycle/min)		Amplitude (mV)		Conduction velocity (cm/sec)	
	Mean	Range	Mean	Range	Mean	Range
At rest	6.2 ± 1.3	5–8	0.59 ± 0.06	0.42–0.74	5.2 ± 0.8	4.2–6.8
During ejaculation	12.6 ± 2.7*	10–16	1.3 ± 0.2*	1.1–1.5	8.3 ± 1.4*	7.4–10.2

[a] Values are given as the mean ± SD.
*$P < 0.05$. P values during ejaculation are compared to that at rest.

ejaculation and at intervals of 0.6–1 secs (mean: 0.82 ± 0.03). Each ejaculatory spurt was associated with an increase in the electric activity of the TA. The number of bouts of increased electric waves varied from 3 to 5 (mean: 3.8 ± 0.3). After completion of ejaculation, the electric activity of the TA returned to the resting stage.

Discussion

The current study could shed some light on the functional relation of the TA to the testicular tissue. This study has shown that the TA is not just an inert covering to the testicle; it seems to be an "active" one that might have a role in testicular function. The presence of SMCs in the TA appears to be responsible for evoking the recorded resting electric activity that apparently lends a resting tone to the TA.

The exact role of the resting TA tone in the testicular function is not known. However, we assume that, at rest, the muscular tone of the TA could add support to the testicular tissue in addition to that effected by the connective tissue elements of the TA. It is likely that the impregnation of the TA connective tissue with smooth muscle fibers might assist the testicle to adapt to its functional performance, in particular during sexual intercourse.

The testicle undergoes certain changes during the different phases of the sexual act (13). Thus, in the excitement phase, the testicle becomes slightly elevated and the scrotal skin is thickened, which is probably due to dartos muscle contraction. This is followed in the plateau stage by an increase in the testicular size. Changes in the scrotal skin and testicles continue until the orgasmic phase is completed. In the resolution phase, the testicles and scrotal skin return to the pre-excitement phase.

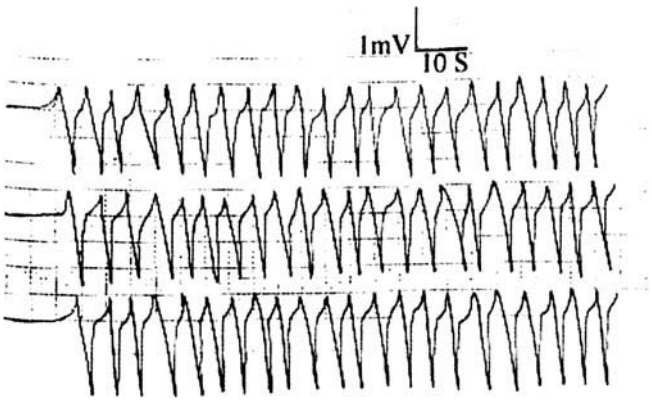

Figure 3. Electric waves recorded at ejaculation from the electrodes applied to the TA.

During ejaculation, the significant increase in the electric waves, which coincides with the episodes of semen spurts, presumably denotes contraction of the SMCs in the TA. Histochemical approaches have shown the TA to contain contractile elements (14). The significance of the contraction of the SMCs in the TA during ejaculation needs to be discussed. It appears that the intermittent successive TA contractions at ejaculation assist in squeezing the testicular secretions toward the epididymis and the vas deferens. Furthermore, the massaging effect induced by the intermittent contractions of the SMCs in the TA may also act to increase the testicular circulation during ejaculation, which might explain the increase in the testicular size during the plateau stage. The blood vessels to the testicles pass through the TA. Thus, the intermittent contractions of the SMCs in the TA at ejaculation seem increase the blood pumping to the testicle, with a resulting increase in the testicular circulation and size. After the termination of ejaculation, the return of the electric waves of the TA to the resting stage presumably denotes that the contractile activity of the SMCs in the TA has returned to the resting tone.

It is thus assumed that the testicular TA plays a role in the testicular function. Testicular capsulotomy resulted in germ cell degeneration and reduction in endogenous luteinizing hormone (8, 9). Lesions of the TA might affect the testicular function, possibly by interfering with the intermittent TA contractions and testicular circulation. The effect of absence or decrease of muscle fibers of the TA on the testicular function, in particular during ejaculation, is not known. In patients with constrictive albuginitis, the TA was thick and fibrosed, forming a tight covering to the testicle (15). Biopsy of the TA showed excessive fibrous tissue that replaced the smooth muscle fibers; there were areas of hyalinization, but no inflammatory cells were encountered. Testicular biopsy revealed degenerative changes of the seminiferous tubules, and the patients were infertile (15).

In conclusion, the TA is not an inert covering to the testicle, but it seems to have a functional activity and a resting tone, as evidenced by the recording of resting electric waves that are presumably evoked by the SMCs in the TA. The resting tone appears to support the testicular tissue. During ejaculation, the increased electric activity in the TA, which coincides with semen spurt episodes, presumably denotes TA contractions. These intermittent TA contractions seem to assist in massaging the testicular secretions toward the epididymis and the vas deferens and augment testicular circulation. The effect of pathologic conditions of the TA on ejaculation needs to be studied.

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