EFFECTS OF VASECTOMY ON THE REPRODUCTIVE SYSTEM AND SEXUAL BEHAVIOUR OF RATS

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Summary. Sexually mature rats were bilaterally or unilaterally vasectomized or subjected to sham-operation at intervals of up to 1 year before autopsy. The gross morphology of the gonads and accessory glands was unaffected by vasectomy although epididymal enlargement was observed in some rats shortly after surgery. Sperm-containing cysts were found near the cut ends of the deferent ducts and in the abdominal cavity. Sexual behaviour was similarly uninfluenced by vasectomy although the animals of one group, vasectomized on the left side only, failed to ejaculate. The significance of this observation is considered.

INTRODUCTION

Vasectomy continues to be a common means of male sterilization (Fried, 1972; Holden, 1972; Gillette, 1972) despite the fact that older studies (see reviews by Moore, 1926; Jhaver & Ohri, 1960) and more recent investigations present contrasting conclusions regarding the effects of the operation. For example, macroscopic or histological changes in the testes of animals following occlusion of the ductus deferens were noted by Rangam, Arora & Gupta (1957), Laumas & Uniyal (1967), Sadi, Chiorboli & Saad (1967), Grewal & Sachan (1968), Thakur, Sheth & Rao (1972) and Sackler, Weltman, Pandhi & Schwartz (1973), while little or no postoperative testicular change was observed by Smith (1962), Kar, Chandra, & Kamboj (1965), Swanson & Hafs (1969), Paufler & Foote (1969), Kubota (1969), Igboeli & Rakha (1970), Segal (1972) or Plaut (1973).

The effects of vasectomy on the sexual behaviour of men has been investigated by means of questionnaires (Rodgers & Ziegler, 1968; Fried, 1972; Hulka & Davis, 1972) and Phoenix (1973) analysed the sexual behaviour of rhesus monkeys 1 month after vasectomy. We are not aware of other animal studies in this field but it is generally assumed that the sexual behaviour of animals is unaffected by vasectomy (see Kuehn & Beach, 1963).

This report concerns the effects of bilateral or unilateral vasectomy and of sham operations on the morphology of the reproductive system and on the sexual behaviour of rats up to 1 year after operation.

MATERIALS AND METHODS

Locally raised Wistar rats in groups of about five animals of mixed surgical treatment were housed in 57×51×34 cm cages and were maintained on a 12-hr light/12-hr dark cycle (lights off at 19.00 hours) with ample water and Purina Rat Chow.

Four groups, each containing fifteen males between 90 and 120 days old, were subjected to surgery at the following intervals before being killed: 12 months (Group I), 9 months (Group II), 4 months (Group III), and 2 months (Group IV). Within groups, five animals were bilaterally vasectomized (B), five were unilaterally vasectomized (U), and five were subjected to bilateral sham operation (S).

Surgery was performed under ether and sterile precautions were strictly observed. A transverse incision approximately 1 cm in length was made across the ventral scrotal mid-line about 3 mm posterior to the prepuce. Intrascrotal connective tissue lateral to the penis was separated with splinter forceps while carefully avoiding damage to the penis. The ductus deferens was freed from the fat body lying anterior to the testis. Splinter forceps were used to split the connective tissue sheath and muscularis of the ductus deferens opposite the vasal artery. The ends of the split ductus sheath and muscularis were then gently separated avoiding damage to adjacent blood vessels and exposing about 1 cm of the intact lamina propria of the duct. A segment of the duct lining about 0.5 cm long was resected and the cut ends were reflected back on themselves and tied in place with 3-0 black silk. The ligated ends were then replaced in the fat body and the scrotal incision was closed with black silk and mattress sutures. Powdered sulphathiazole was applied to the closed incision. The scrotal sacs were palpated to ascertain that the testes had not been displaced. In U operations, the above procedure was performed on one side while, on the contralateral side, the duct was cleared from the fat body and then replaced undamaged. In S operations, the deferent ducts were handled as on the contralateral side in U animals.

Sexual behaviour was evaluated about 1 month before autopsy. Each male had one trial nightly at 4-day intervals for a total of three trials. Trials were conducted between 19.00 and 22.00 hours and lasted 10 min or until the male ejaculated (see Feder, 1971). Tests were held in the male's home cage and involved removing all males from the cage, returning them singly to the cage for a three minute acclimatization period, and then placing a spayed female treated with oestrogen and progesterone (Edwards, Whalen & Nadler, 1968) into the cage for the trial. The parameters of masculine behaviour recorded were nosing or body nibbling latency, frequencies of correctly orientated mounting without pelvic thrusting, frequency of mounting with pelvic thrusting, intromission frequency and latency, and ejaculation latency. The characteristics of these patterns of behaviour have been detailed by Young (1961), Kuehn & Beach (1963) and Feder (1967, 1971).

Males were killed by cervical dislocation and their body weights were recorded. The testes and epididymides were cleaned from fat and connective tissue and weighed. The seminal vesicles were dissected free of the coagulating

Table 1. Testicular, epididymal and seminal vesicle-coagulating gland weights of adult rats in four groups examined at different times after vasectomy or sham operation

	Testis wt		Epididymis wt		Seminal vesicle-coagulating gland wt	
	Right	Left	Right	Left	Right	Left
Group I (12 months)						
S	342.6 ± 64.6 (3)	344.8 ± 54.0 (3)	97.2 ± 13.9 (3)	98.6 ± 11.1 (3)	183.8 ± 29.2 (3)	168.6 ± 36.8 (3)
B	371.3 ± 70.0 (3)	356.5 ± 52.9 (3)	117.9 ± 27.1 (3)	159.3 ± 102.2 (3)	214.1 ± 46.5 (3)	213.2 ± 40.2 (3)
U	306.3 ± 62.3 (5)	272.3 ± 64.4 (5)	88.1 ± 21.0 (5)	102.4 ± 70.8 (5)	165.2 ± 39.9 (5)	180.1 ± 39.0 (3)
Group II (9 months)						
S	302.5 ± 20.5 (4)	308.7 ± 20.4 (4)	92.9 ± 8.6 (4)	94.4 ± 11.2 (4)	233.2 ± 142.0 (4)	200.0 ± 93.1 (4)
B	334.7 ± 34.4 (5)	299.1 ± 109.9 (5)	96.9 ± 7.5 (5)	89.0 ± 22.9 (5)	190.7 ± 45.0 (5)	192.3 ± 52.2 (5)
U	316.5 ± 30.9 (4)	303.9 ± 45.7 (4)	88.5 ± 6.6 (4)	87.7 ± 6.4 (4)	168.4 ± 27.0 (4)	170.7 ± 29.1 (3)
Group III (4 months)						
S	394.2 ± 60.6 (5)	394.1 ± 57.4 (5)	116.0 ± 15.6 (5)	110.9 ± 13.1 (5)	166.2 ± 24.6 (5)	170.8 ± 24.6 (5)
B	405.4 ± 45.0 (5)	408.0 ± 42.6 (5)	130.6 ± 16.5 (5)	129.1 ± 12.0 (5)	185.0 ± 31.8 (5)	183.7 ± 28.2 (5)
U	390.8 ± 77.3 (5)	399.2 ± 45.3 (5)	124.4 ± 46.3 (5)	119.1 ± 14.2 (5)	173.0 ± 22.4 (5)	174.8 ± 22.0 (5)
Group IV (2 months)						
S	398.5 ± 34.7 (5)	403.5 ± 31.7 (5)	119.2 ± 12.6 (5)	117.8 ± 13.7 (5)	181.8 ± 41.2 (5)	174.0 ± 30.1 (4)
B	412.2 ± 44.1 (4)	410.4 ± 49.3 (4)	119.1 ± 4.7 (4)	184.6 ± 46.2* (4)	173.7 ± 9.8 (4)	168.4 ± 8.2 (4)
U	391.4 ± 10.8 (5)	369.1 ± 44.6 (5)	121.3 ± 16.5 (5)	108.5 ± 24.4 (5)	171.4 ± 28.8 (5)	161.7 ± 23.8 (5)

S = sham operation; B = bilateral vasectomy; U = unilateral vasectomy. The values are expressed as mean ± S.D. in mg/100 g body weight. The numbers in parentheses are sample sizes.

* Significantly different from the control value, $P < 0.05$.

glands and prostate and their fresh weights were recorded. Cysts from the abdominal cavity resembling those described by Sackler *et al.* (1973) were fixed in Bouin's fluid or 10% paraformaldehyde buffered with 0.2 M-S-collidine (Winborn & Seelig, 1970) for study by light and electron microscopy, respectively.

A two-tailed Mann-Whitney U-test was used to test for statistical significance unless otherwise noted. Probability values less than or equal to 0.05 were considered significant.

RESULTS

Seven animals died during the course of the experiment. Autopsy findings suggested that their deaths were unrelated to vasectomy or sham operation. Of the remaining rats, comparisons of weights of testes, epididymides, and

Table 2. The sexual behaviour of rats in four groups tested at different times after vasectomy or sham operation

	Nosing latency (sec)	Mounts without pelvic thrusting	Mounts with pelvic thrusting	Intromissions	Trials with ejaculations	Ejaculation latency (sec)
Group I (11 months)						
S (9)	25.3 ± 19.9	2.9 ± 0.8	21.6 ± 8.6	19.7 ± 18.0	4	447 ± 141
B (9)	36.7 ± 30.6	1.7 ± 1.6	27.5 ± 7.9	17.9 ± 4.7	2	500 ± 70
U (15)	13.4 ± 6.1	0.8 ± 0.4*	8.2 ± 8.3	6.2 ± 7.0	0*	—
Group II (8 months)						
S (12)	59.8 ± 49.4	2.0 ± 2.4	14.3 ± 17.2	7.1 ± 7.1	1	—
B (15)	33.8 ± 15.0	1.0 ± 1.7	6.0 ± 8.0	8.2 ± 8.2	1	—
U (12)	16.0 ± 5.4	2.8 ± 2.2	13.5 ± 15.3	6.4 ± 5.7	1	—
Group III (3 months)						
S (15)	17.6 ± 6.7	1.5 ± 1.6	12.8 ± 6.7	11.2 ± 7.9	3	472 ± 14
B (15)	76.2 ± 12.3	3.6 ± 4.7	15.6 ± 11.7	28.9 ± 20.5	5	323 ± 122
U (15)	18.4 ± 10.0	2.8 ± 3.1	20.8 ± 9.2	29.7 ± 18.0	7	377 ± 99
Group IV (1 month)						
S (15)	27.4 ± 27.2	3.5 ± 3.3	20.4 ± 15.6	32.0 ± 12.3	7	413 ± 119
B (12)	15.5 ± 4.1	1.1 ± 1.6	23.5 ± 7.2	36.2 ± 18.1	8	381 ± 122
U (15)	27.8 ± 22.9	3.4 ± 2.6	13.6 ± 4.9	17.7 ± 18.7	6	392 ± 120

S = sham operation; B = bilateral vasectomy; U = unilateral vasectomy. Figures in parentheses represent the number of trials. All values, except those for 'Trials with ejaculations', expressed as means ± S.D.

* Significant at 0.05 level when compared to S animals of the same group.

seminal vesicles between S and B or S and U rats revealed no significant variations in Groups I, II, and III. In Group IV, however, the mean weights of the left epididymides of B and S rats differed significantly (Table 1). Yellowish cysts were located on the left cauda epididymidis of three of these B animals and may have been responsible for the weight increase.

Cysts (0.5 to 2.5 cm diam.) were found at the testicular ends of the cut deferent ducts in nearly all B and U animals. Cysts were occasionally found on the

caudae epididymides of B rats in all groups and of the U rats in Groups I, II and III. Small yellowish cysts were observed in intestinal and splenic mesenteries of three B (Groups III and IV) and two U (Groups I and III) rats. Histological study of abdominal cysts revealed the presence of a fibrous outer wall and a cavity containing what appeared to be masses of spermatozoa. Electron microscopy confirmed the presence of spermatozoa in these cysts. Amorphous necrotic material was observed in the cysts but macrophages were not detected.

Small, soft, purplish testes were found unilaterally in four rats: a single U rat from each of Groups I, III, and IV and a B rat from Group II. Adhesions between the cut testicular ends of the deferent ducts and scrotal linings were seen in Group I, II and III rats associated with a small testis. Abnormal testes were consistently accompanied by small translucent epididymides.

Analysis of the parameters of sexual behaviour showed no significant differences in S versus B or S versus U animals in Groups II, III and IV. Similar comparisons in Group I, however, suggested that U animals exhibited fewer mounts with pelvic thrusting and had a lower proportion of trials with ejaculation (Table 2).

DISCUSSION

Our results suggest that vasectomy in the rat is accompanied by transient, self-correcting, and minor changes in the reproductive system. Increased epididymal weight was observed shortly after vasectomy, and was attributable to cysts in the cauda epididymidis. Smith (1962) and Sackler *et al.* (1973) made similar observations in rats and it has been suggested that epididymal cysts are the consequence of slow sperm resorption after occlusion of the ductus deferens (Swanson & Hafs, 1969; Moniem & Glover, 1972; Sackler *et al.*, 1973). Cysts at the cut ends of the deferent ducts have been observed in rats (Rangam *et al.*, 1957; Smith, 1962; Mullaney, 1962; Flickinger, 1972; Sackler *et al.*, 1973), bulls (Igboeli & Rakha, 1970) and man (Phadke & Phadke, 1967; Hulka & Davis, 1972). Hulka & Davis (1972) suggested that the cysts were a reaction to slow leakage of spermatozoa from incompletely sealed cut ends of the ductus deferens. Smith (1962) observed dense suspensions of spermatozoa in similar cysts and reported a dramatic decline in their size between 40 and 90 days after operation. Leakage of spermatozoa may have accounted for cysts in the present study but large cysts were found 4, 9 and 12 months after vasectomy. Small, sperm-containing cysts in abdominal mesenteries may also have resulted from slow leakage of spermatozoa. Sperm movement in the abdominal cavity and mechanisms of abdominal cyst formation require further investigation.

Sackler *et al.* (1973) reported both bilateral and unilateral small testes in twenty-one of thirty-one vasectomized rats. Small abnormal testes were found in four of fifty-three rats in the present study. We suspect that factors other than vasectomy were responsible for the testicular degeneration. The vasal artery of a single Group I animal with a small testis was damaged during the operation and the degenerative effects of ischaemia on the testes and epididymides are well documented (Moore, 1926; Harrison, 1953; Macmillan, 1953). Two other

animals with a small testis in this study exhibited adhesions between the cut ends of the ductus deferens and the scrotal lining. Such adhesions may have interfered with testicular temperature regulation and thereby promoted testicular degeneration (see Moore & Quick, 1924). The results of Sackler *et al.* (1973) may have reflected their use of immature rats although Segal (1972) observed no dramatic testicular changes after vasoligation in immature rats. Plaut (1973) reported no significant changes in testicular size after vasectomy of adult rats and offered the suggestion that "deleterious effects of vasectomy may result from procedural artifacts".

The absence of any observed effects of vasectomy on the sexual behaviour of the rats in Groups II, III and IV are in agreement with observations of vasectomized rhesus monkeys by Phoenix (1973). Significant alterations after unilateral vasectomy in Group I rats may have reflected surgical trauma since the rats in this group were vasectomized on the left side while all subsequent unilateral vasectomies were performed on the right side. Of particular importance in this context is the observation by Plaut (1973) that responses of right and left testes to vasectomy differed in that the left testis did not increase in size after operation while the right did. Plaut (1973) suggested that right-left testicular circulatory differences may have influenced right-left differences in testicular morphology after vasectomy. Relationships between side-related morphological differences and behavioural responses remain obscure.

We conclude that vasectomy of rats does not alter gross testicular morphology or androgen production as reflected by accessory gland weight, and that the sexual behaviour of vasectomized rats is equivalent to that of controls.

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