RADIOLOGICAL OBSERVATIONS ON ELECTRICALLY-INDUCED EJACULATION IN THE RAM

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(Received 7th October 1968)

Summary. Observations on the urogenital tract were made radiologically in six rams. Contrast medium was first introduced to the urethra or vas deferens before electrical stimulation was applied *per rectum* and later to the vas during a series of stimuli to induce ejaculation.

Without stimulation, contrast medium reaching the pelvic urethra from either the penile urethra or the ampulla was generally expelled in a retrograde manner to the bladder, while residual material in the penile urethra was voided.

Ejaculation took place only during pauses between stimuli, fluid being discharged from the ampulla straight through into the penile urethra. This main discharge was followed by some reflux of fluid from the pelvic urethra to the bladder. At rest, no fluid remained in either the pelvic or the penile urethra.

INTRODUCTION

An electrical technique for collecting semen from rams was reported more than 30 years ago (Gunn, 1936). Since then, more precise methods of applying stimuli have been used for the induction of ejaculation in this species but the physiological responses of the urogenital structures involved have not been investigated conclusively. Most attention has been directed to the types of electrical circuit developed but with less emphasis placed on the design of electrodes although bipolar rectal probes are widely accepted. The following observations, made in conjunction with an experiment designed primarily to elucidate the function of the vesical sphincters (Essenhigh, Ardran, Hovell & Smith, 1969), are recorded as a further contribution to an understanding of the ejaculatory process when procured by electrical stimulation applied *per rectum*.

MATERIAL AND METHODS

Rams

Six Welsh Mountain ram lambs aged approximately 7 to 8 months were available for this series of experiments. They weighed between 20·0 and 27·5 kg

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after shearing and immediately before experiment. This size of animal was chosen in order that clear radiographs could be obtained with the animals intact. Clinical examinations of the rams' genitalia were carried out and semen was collected from each ram on at least one occasion before use to ascertain normality and that puberty had been reached.

Anaesthesia

After starvation overnight, general anaesthesia was induced intravenously with pentobarbitone sodium (Nembutal) and maintained for periods of 2½ to 3 hr with further doses given through an indwelling jugular catheter. The maintenance doses were approximately one third of that administered initially and given at about 30-min intervals or as required. A rest was placed under the ram's neck to minimize the risk of inhalation of salivary fluid or ruminal contents. In addition, on several occasions an endotracheal tube was inserted for the same reason.

Rectal probe

Electrical stimulation of 3 sec duration, with pauses of a similar length, was applied with a bipolar rectal electrode which had been lubricated and inserted to a depth of 12.5 cm. The anterior end of the probe was depressed ventrally to approximate to the ampullae of the vasa deferentia. In the later experiments, a rectal probe of smaller diameter, 2.0 cm, was used which was more suitable for ram lambs. This also had rings made from aluminium (1 mm thick), plated with tin, which did not obscure vital structures on radiographs as the brass poles on the original probe had done (Pl. 1, Fig. 1).

Electrical circuit

The stimulus was supplied by a transistorized circuit with batteries which could be connected to give variable total voltages. This was a modification of the circuit described by Nichols & Edgar (1964). The current was 60 mA at 6 volts with a frequency of 70 cycles per sec when measured across a fixed resistance of 100 ohms. The wave form was rectangular, with a pulse width of 1.0 m-sec duration separated by intervals of 13.0 m-sec.

Contrast medium

Contrast medium (40% Hypaque, Sodium diatrizoate) was introduced to the urogenital tract either through the left vas deferens or by means of a

EXPLANATION OF PLATE 1

FIG. 1. Photograph of rectal portion of bipolar perspex electrodes. The lower electrode is larger in diameter and has solid plated brass poles. The upper electrode, more suitable for radiographic purposes, has tin-plated aluminium poles in the form of bands.

FIG. 2. (a) Line drawing showing main anatomical features with original electrode in position. The vas deferens is represented by the single line drawn obliquely from right to left.

(b) Radiograph from which (a) was prepared. The sigmoid flexure of the urethra has been extended.

(c) Radiograph with the smaller improved electrode in position and showing normal disposition of the sigmoid flexure.

(d) Enlargement of pelvic urethra (as in c) and showing bulb and valve which prevent the free passage of a urethral catheter.

PLATE 1

(Facing p. 385)

urethral catheter, depending on the site to be examined (Pl. 1, Fig. 2a, b, c). The vas deferens was intubated at the neck of the scrotum on the ventral aspect, while a satisfactory site for entry to the urethra was found at the base of the processus urethrae. Experience had shown that the urethral orifice and the free portion of the processus were too narrow to offer ready access. An incision made in the attached part allowed the unobstructed passage of a catheter into the urethra towards the bladder. Even when the sigmoid flexure had been straightened, however, by maximum protrusion of the penis from the prepuce, it proved impractical to pass the catheter beyond the bulb at the external bladder sphincter as it was deflected by a valve at this point (Pl. 1, Fig. 2d).

Recordings

The rams were placed on their right side for all radiographic recordings. Still radiographs were used to record anatomical details and to ensure the correct positioning of the animal in relation to the camera. Cinefluorograms were taken to record the flow of contrast medium during a series of stimuli and also in the absence of stimulation. Allowance had to be made for forward movement during stimulation when there was extension of the musculature of the hindquarters.

Terminology

'Ejaculation' in the context of this paper is used where it was demonstrated radiographically that the ampulla of the vas deferens discharged most of its contents into the urethra external to the voluntary sphincter. This was not necessarily associated with erection of the penis or the appearance of fluid at the urethral orifice, nor does it imply that the accessory glands were contributing normally to the ejaculate.

RESULTS

Observations were made at rest when the vas or urethra was filled with contrast medium as a continuous or interrupted process and again when the ram was stimulated.

At rest

The penile urethra was filled without difficulty with contrast medium through a urethral catheter. Any fluid which passed proximally into the pelvic urethra

EXPLANATION OF PLATE 2

FIG. 3. (a) Radiograph showing ampulla filled with contrast medium, reflux into the bladder and the penile urethra part-filled. Air had been injected into the bladder to create greater contrast and a large volume of hypaque was introduced to the vas.

(b) Line diagram of radiograph (a).

FIG. 4. (a) Cinefluorograms of ampulla and pelvic urethra during ejaculation. The proximal pole of the electrode is positioned close to the mid-portion of the ampulla.

(a) Ampulla distended with contrast medium. The posterior urethra is empty. In the top right-hand sector, there is a diffuse pool of contrast medium in the bladder.

(b) Following stimulation, fluid is discharged and the pelvic urethra distal to the tip of the ampulla is now filled.

(c) After the main distal passage of fluid through the pelvic urethra, a jet of contrast medium can be seen refluxing into the bladder.

was rapidly expelled into the bladder. This retrograde expulsion was also seen when sufficient fluid was injected into the vas to pass from the ampulla into the pelvic urethra. If a relatively large volume (5 to 10 ml) was rapidly introduced to the vas, most of the material was discharged into the bladder but some passed into the penile urethra (Pl. 2, Fig. 3a, b). In each case, the pelvic urethra remained empty after its contents were discharged, whether proximally into the bladder or distally into the urethra.

Cinefluorograms taken during these procedures confirmed the evidence of the radiographs. They also showed the manner in which the ampulla was filled and then intermittently expelled its contents into the pelvic urethra.

With stimulation

During a series of three or four stimuli, small volumes (1 to 2 ml) of contrast medium were injected into the vas and cinefluorograms were taken, for the most part at 25 frames per sec. These showed that the ampulla became progressively distended during stimulation, particularly at the distal end. Immediately stimulation ceased and the ram's hindquarters relaxed, the ampulla discharged its contents into the pelvic urethra (Pl. 2, Fig. 4a, b) and through the external sphincter, the sphincter at this time being widely open. The ampulla appeared to empty itself by a succession of rapid muscular contractions. This was confirmed later in one animal by laparotomy, when the contractions were seen to involve the ampullae equally, although one side only had been filled with contrast medium. A feature of the ejaculatory process was that on the majority of occasions, reflux of a small amount of fluid into the bladder occurred following the expulsion of the bulk of the fluid into the urethra distal to the external sphincter. This backflow also took place during the pause between stimuli and was recognized as a small jet of material entering the bladder (Pl. 2, Fig. 4c) as the pelvic urethra again emptied itself.

A number of contractions of the ampulla were required before the penile urethra was filled with contrast medium. In recordings from one ram, it took approximately 2.0 sec for the urethra to fill, but it was emptied more rapidly in 0.15 sec.

DISCUSSION

No difficulty was encountered in stimulating the rams to ejaculate even although they were in a state of general anaesthesia. Ejaculation frequently took place in response to the second or third stimulus. Apparatus based on a design used extensively in veterinary clinical work, but operated generally at lower voltages than is common practice, proved satisfactory. A special electrode was made for this work. It was possibly an advantage that the experiments were carried out at the optimum time in the breeding season.

Although a number of artificial factors existed, namely electrical stimulation, anaesthesia and the introduction of contrast medium to the vas, ejaculation took place only in the pauses between stimuli and in most cases the rams responded to stimuli of the same magnitude as they had done when conscious during the collection of semen clinically. Stimulation might have caused spasm of certain of the structures involved resulting in a transitory inhibition. For these

main reasons, the process of ejaculation as observed may be comparable with the sequence of events in natural mating. The rapid contractions of the ampulla and the very quick emptying of the urethra fit in well with the observed mating behaviour in the ram. Mounting, thrusting and ejaculation are all accomplished within a few seconds. The vas, being an exceedingly narrow structure, was occluded as a result of intubation, so the ampulla could not be recharged with spermatozoa from the epididymis. This did not prevent the ampulla contracting after stimulation and expressing the fluid which had been introduced to the vas. The introduction of this fluid may have contributed to the number of times the rams were successfully stimulated during the experimental periods (up to six or seven times in 2 to 2½ hr), especially when their age was taken into account.

Walton (1960) postulated that ejaculation probably starts with contractions in the walls of the epididymis which then pass along the vas deferens. In the present experiments, ejaculation appeared to start with ampullary contractions. The primary function of the epididymal and vasal contractions therefore may be to recharge the ampullae rather than to initiate the ejaculatory response. At no time was the vas observed to contract in any way although this may have been due to limitations in the experimental method. The same author considered that the entrance of seminal fluid to the bladder was prevented by erection of the crista urethrae and contraction of the bladder sphincter. The current investigation showed that a small quantity of the fluid which had been discharged from the ampulla into the pelvic urethra, was in turn permitted to enter the bladder following the main distal passage of fluid. Essenhig *et al.* (1969) have shown that the 'internal sphincter' at the bladder neck plays little part in the directional flow of fluid during ejaculation as, even when the bladder neck was resected above the level of the prostate, the picture remained essentially the same as in the intact animal.

In the ram, some reflux of semen is probably normal, if not when following all ampullary discharge contractions, then at least following a total ejaculate. This observation is supported in part by the findings of Lino, Braden & Turnbull (1967) that spermatozoa in numbers approaching the total daily production were found in the voided urine of two rams. Our findings would indicate that spermatozoa leaving the ampullae in the absence of a full ejaculatory response or voiding would be expelled back into the bladder from the pelvic urethra.

ACKNOWLEDGMENTS

The authors are grateful for the technical assistance which they received, particularly from Mr W. Dodson, Mr M. Tuckey and Mr R. H. G. Williams.

Acknowledgement is also made to the Editor of the *British Journal of Urology* for permission to publish Figs. 2, 3 and 4.

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