Effect of Stimulation of Autonomic Outflow to Urinary Bladder of Rhesus Monkey.* (27672)

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In the rhesus monkey Elliott(1) has shown that excitation of the sympathetic nerves to the bladder evoked a slight initial contraction at the base, followed immediately by marked relaxation of all portions of the organ. Sherrington(2) also noted a small to moderate initial contraction after stimulation of the anterior roots of L4 and L5 nerves but the latent period often was long and he never detected any appreciable relaxation following the contraction. Both investigators found that stimulation of the sacral outflow produced an immediate vigorous response.

Our earlier studies in the cat and dog(3-5) have clearly established that hypogastric nerve stimulation resulted in an initial contraction of moderate strength of all portions of the detrusor muscle, followed by relaxation of the entire bladder wall during the period of stimulation. Pelvic nerve stimulation in these same animals(6,7) always elicited a prompt, vigorous and well-sustained contraction. The present investigation was undertaken to determine whether or not the function of the autonomic outflow to the bladder in the monkey was the same as in the cat and dog, and to compare our results with those previously reported(1,2).

Methods. Eight rhesus monkeys, divided equally between males and females, and weighing from 2.5 to 4.2 kg, were used. Observations were not recorded from one animal due to camera failure. Light surgical anesthesia was obtained by intraperitoneal injection of pentobarbital sodium. The methods used in stimulating the nerves and recording and tabulating the data have been described (3-5). Following a midventral abdominal incision to expose the bladder and its nerve supply, small squares of adhesive paper (each bearing a central spot of contrasting ink) were placed on the exposed surface of the viscus in such a way as to divide the bladder into 12 segments or areas. By means of a 16-mm camera mounted above the bladder, photographs were made at one second intervals during each experiment. Subsequently, by projecting the film onto suitable paper, measurements were made of the activity taking place in each of the 12 regions during each second of observation. Minimal strength, square wave stimuli were employed at frequencies ranging from 10 to 100 per second. The hypogastric nerves were stimulated near their origin just caudal to the inferior mesenteric ganglion. All pelvic nerves were stimulated unilaterally. Kymograph tracings of total bladder response under conditions of constant intravesical pressure for each experiment were recorded.

Results. Electrical stimulation of intact hypogastric nerves occasionally evoked a weak, often poorly defined, bladder response. In one animal, stimulation elicited a slowly developing contraction in many areas of the bladder wall (Fig. 1, Exp. 2). Restimulation of the same nerves 9 minutes later (Exp. 4) gave similar results except that while some regions were contracting, others were undergoing relaxation. In another monkey (M5, female), stimulation of intact hypogastric nerves at a frequency of 30 per second, a stimulus duration of 6 msec and intravesical pressure held constant at 4.5 cm water, produced a moderate bladder contraction but with only slight regional activity. Restimulation of the same nerves at a frequency of 100 per second evoked no appreciable change in response. Section of these nerves and stimulation of their peripheral cut ends at the same frequency did not alter the response. This was true also for another female (M8) in which the hypogastric nerves were stimulated before and after section.

Rhythmic contractions of the bladder wall were observed visually during many of the experiments on the hypogastric nerves. In one female (M4), in which the hypogastrics

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FIG. 1-3 are outline sketches of ventral surface of bladder representing activity taking place per unit length of muscle in each of 12 areas. Each area of activity measured has been placed as nearly as possible to its actual position on the bladder wall. Each graph represents a complete observation from a single segment. Each circle in each graph represents activity during each second of observation. Onset of stimulation coincides with first circle in each graph. Cessation of stimulation represented by arrow (except Exp. 2, Fig. 1). Insert: Kymograph record of bladder volume during each observation. A rising curve indicates contraction; a falling curve, relaxation.

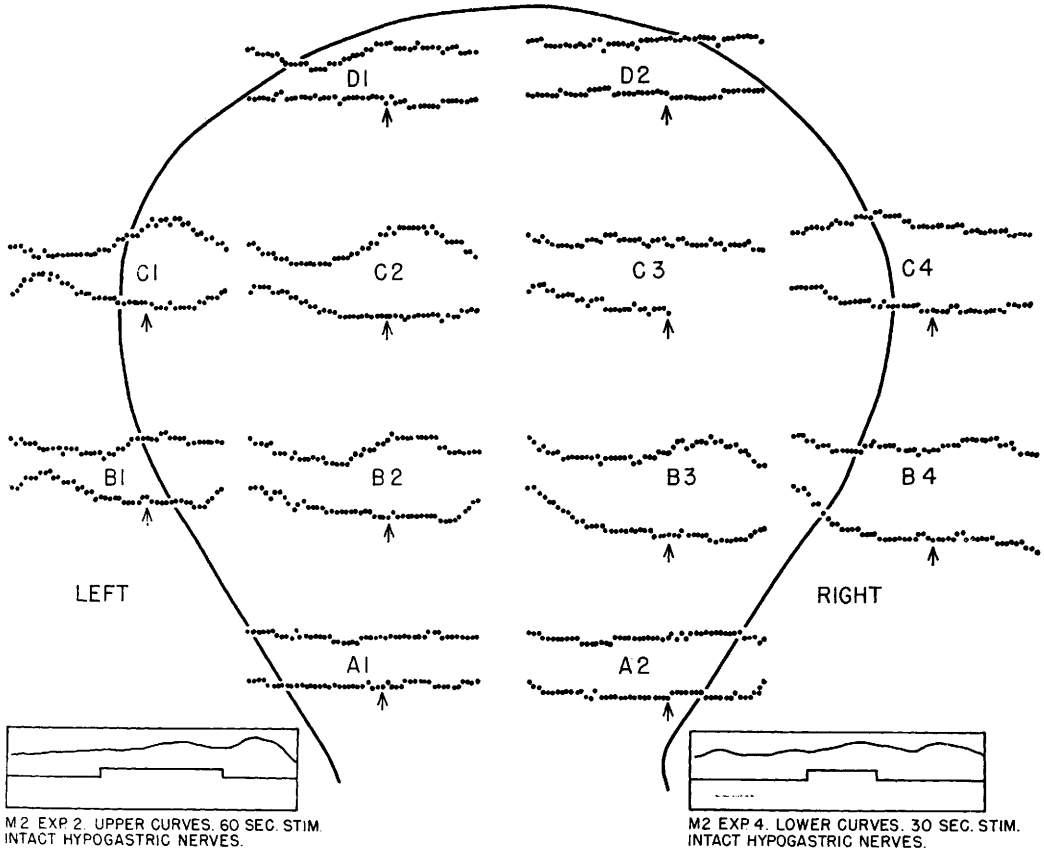

FIG. 1. Bladder responses in a male (M2) following bilateral stimulation of hypogastric nerves at a frequency of 30 per sec, a duration of 8 msec, and intravesical pressure held constant at 11 cm water. All nerves intact.

were stimulated at frequencies of 10, 30 and 60 per second (with a stimulus duration of 5 msec), rhythmic contractions and relaxations were noted in all 3 observations. The contraction would start on one side of the bladder, then sweep in a wave-like motion across to the other side. In many animals this wave involved the whole fundus but frequently only a small portion of the wall exhibited the rhythm. Usually accompanying the rhythm was slight diminution of volume together with a measurable regional activity of the bladder wall.

In contrast to the general ineffectiveness of hypogastric nerve stimulation, excitation of the pelvic outflow always elicited a vigorous and well-sustained contraction of the detrusor muscle. In a typical study (Fig. 2) the right (Exp. 5), and then the left pelvic nerves (Exp. 7) were stimulated. The response to stimulation of the right parasympathetics was a delayed, but very vigorous, contraction on the homolateral side with a generally weaker response on the opposite side. The initial relaxation preceding the contraction in this observation probably was due to spontaneous rhythm in the bladder (Exp. 5, insert). Unlike the right side, stimulation of the left pelvic nerves instituted an immediate contrac-

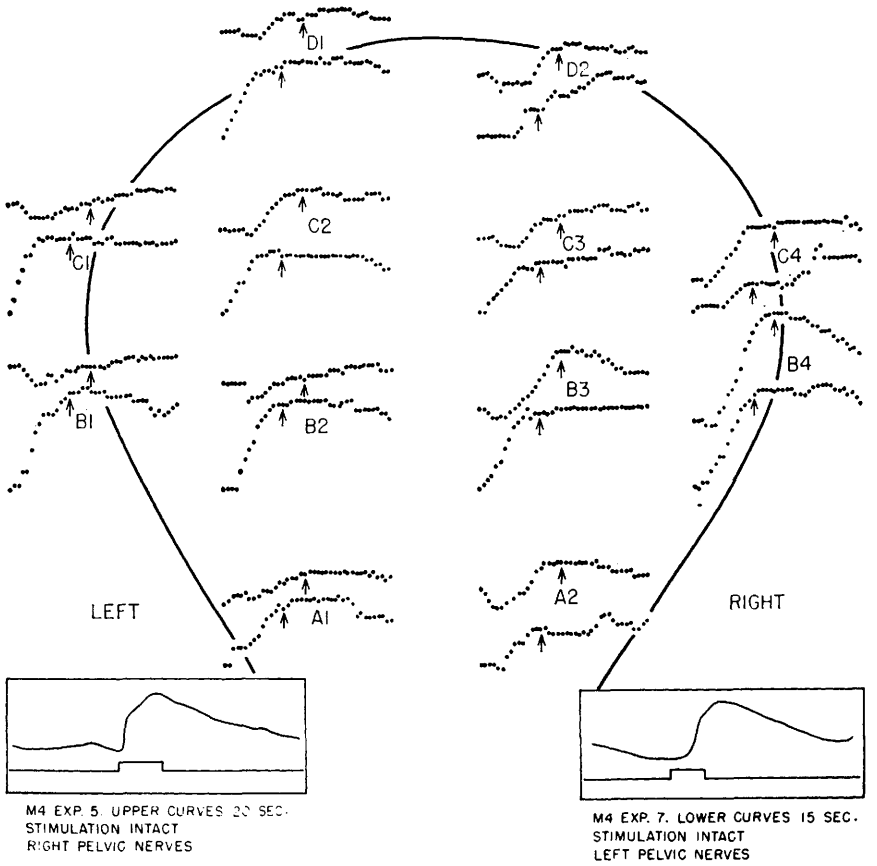

FIG. 2. Bladder responses in a female (M4) following unilateral stimulation of pelvic nerves at a frequency of 30 per sec, a stimulus duration of 5 msec, and intravesical pressure held constant at 4.5 cm water. All nerves intact.

tion in which all regions of the bladder participated (Exp. 7). Moreover, the response was vigorous and well sustained. It was not affected by lowering the frequency to 10 per second or section of the nerves and stimulation of their peripheral cut ends (not shown in figure). In another animal (female, M8) stimulation of the intact left pelvic nerves (at a frequency of 20 per second, stimulus duration of 8 msec and intravesical pressure held constant at 9.3 cm water) elicited a marked contraction. Section of these nerves and stimulation of their peripheral cut ends gave an almost identical response.

Not all parasympathetic nerves influence bladder function to the same extent. In one monkey (Fig. 3), although the right pelvic nerves affected both sides of the bladder equally (Exp. 10), excitation of the left pelvic nerves produced a response in only the lateral and central areas of the stimulated side (Exp. 12).

Discussion and conclusions. These data indicate that stimulation of the hypogastric nerves, unlike those previously recorded in the cat and dog, and by others in the monkey (1,2), were largely ineffective. The usual response was a weak contraction which appeared after 15 to 20 seconds of stimulation and was always difficult to distinguish from normal, spontaneous rhythm of the bladder. Often there was no response to sympathetic nerve stimulation. On the other hand, excitation of pelvic nerves evoked contractions similar in almost all respects to those obtained in the cat and dog and by others in the monkey (1,2).

Altering the frequency of the current,

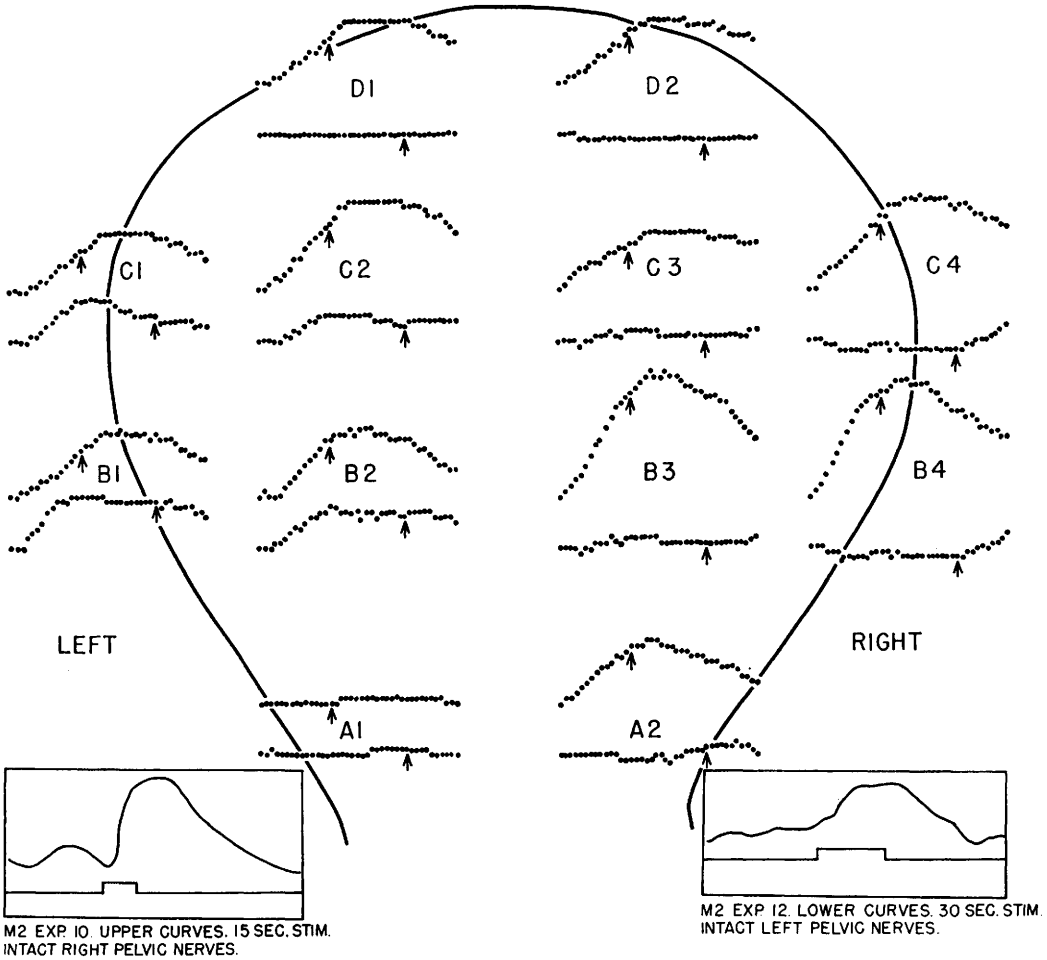

FIG. 3. Bladder responses in the monkey M2 following unilateral stimulation of pelvic nerves at a frequency of 20 per sec, a stimulus duration of 8 msec, and intravesical pressure held constant at 11 cm water. All nerves intact.

changing intravesical pressure, or section of the nerves and stimulation of their peripheral cut ends, had no effect upon the response following either hypogastric or pelvic nerve stimulation. Bladder responses in both males and females apparently were the same.

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