

be accompanied by the same symptoms. In their follow-up study of a large series of patients with chronic nephritis complicated by pregnancy, Stander and Peckham have shown that 40 per cent of these women died within ten years after the diagnosis was definitely established. This shows the grave prognosis of the condition and the importance of recognizing early in pregnancy an underlying nephritis so that the patient may be given the proper treatment. Dr. Stander regards nephritis complicated by pregnancy as a distinct and separate entity or disease process from eclampsia and preeclampsia. Blood studies, the subsequent history of the patient and the kidney function tests all support this contention. He has seen no patient in whom the diagnosis of nephritis complicated by pregnancy was established beyond doubt by chemical and laboratory observations, including repeated kidney function tests, who was cured of the nephritis during, after or by a pregnancy.

BLADDER ABNORMALITIES DUE TO INJURY OF MOTOR PATHWAYS IN THE NERVOUS SYSTEM

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It is important to recognize and catalogue the changes in micturition that may be produced by neurologic lesions. It is necessary to deal not only with trunks of sympathetic and parasympathetic fibers that supply the bladder but also with reflex arcs in the brain and cord extending as high as the cerebral cortex. Lesions may occur on the sensory or on the motor side of the reflex arc. The loss of sensory impulses may give rise to variable symptoms, depending on the level in the nervous system at which the fibers are interrupted and on the sensory pathways that are damaged. Tabes dorsalis furnishes a good example of an interruption of the sensory fibers in the posterior roots producing vesical symptoms. In this paper we discuss lesions of the motor pathways from the brain that influence the bladder. Of these long motor pathways two are known, one arising in the cerebral motor cortex and one in the midbrain.¹

The present study is based on physiologic experiments reported some years ago by one of us.² Later we discussed at some length the neurophysiology of the bladder in connection with lesions of the spinal cord.³ The reader is referred to these earlier reports for a consideration of fundamental theories concerning the function of the smooth muscle of the bladder wall in relation to its nerve supply.

METHODS

Under the heading of methods we consider the general principles of a successful apparatus. We feel that manometers utilizing water instead of mercury should be used for several reasons. The waves of contraction

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1. Langworthy, O. R., and Kolb, L. C.: Demonstration of Encephalic Control of Micturition by Electrical Stimulation, *Bull. Johns Hopkins Hosp.* 56: 37 (Jan.) 1935.

2. Langworthy, O. R., and Kolb, L. C.: The Encephalic Control of Tone in the Musculature of the Urinary Bladder, *Brain* 56: 371 (Dec.) 1933.

3. Langworthy, O. R., and Lewis, L. G.: Urgency and Frequency of Micturition in Neurological Disease, *Bull. Johns Hopkins Hosp.* 56: 211 (April) 1935.

during filling will be found of great importance in reaching conclusions concerning detrusor activity. These waves are greatly damped or even lost by the inertia of mercury. An air-water system will at once record any rise or fall in intravesical pressure.

Another advantage of the water manometer is the inexpensiveness of the material required. With a few lengths of glass and rubber tubing it is possible to construct an apparatus that is adequate in every respect and that can be sterilized.

The instrument is shown in figure 1. A soft rubber catheter was inserted through the urethra into the bladder. This was connected by a T tube with a source of sterile fluid and with the manometer. We not only recorded the intravesical pressure during filling by measuring the height of fluid in the glass tube but also made records on a kymograph. We could not have reached certain conclusions concerning waves of vesical pressure unless these graphs had been available.

Respiratory waves may be differentiated easily from the slow waves of contraction of the bladder muscle. We noted any changes in pressure due to coughing, straining or movements on the part of the patient. The patient should lie flat on the back and remain as quiet as possible during the readings. Toward the end of filling, in certain cases in which it was of interest, the patient was asked to attempt micturition, and the subsequent rise of pressure was recorded. The type of graphic record that is obtained varies with the method of bladder filling. It is most satisfactory to introduce the fluid in equal portions (25 or 50 cc. at one time) and record the behavior of the bladder in the intervals. By this method

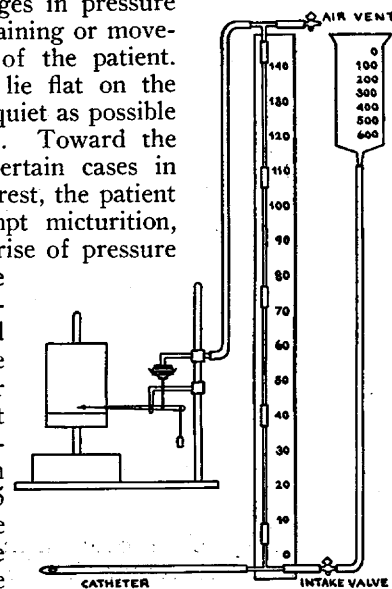


Fig. 1.—Apparatus.

it is possible to see the reaction of the muscle to sudden stretch and to measure the time required for the pressure to reach a resting level in accommodation to the new volume. The activity of the stretch reflex, which is of fundamental importance in the activity of the muscle, is tested in this way.

In this paper only the activity of the detrusor muscle is considered, and the pressure at which the sphincters opened. It is clear that the detrusor muscle normally is adapted for the storing of urine and that its contraction initiates micturition.

There is a certain distortion of the graphic record, owing to the stretch coefficient of the rubber diaphragm in the tambour. The rubber stretches markedly with slight increase in pressure, but the stretch is proportionately less marked as the pressure rises. Therefore slight changes when the pressure is low are magnified out of proportion to the changes at higher pressures.

CYSTOMETRIC READING MADE FROM A PATIENT WITH NORMAL BLADDER INNERVATION

The cystometric reading that is discussed as normal was made on a patient with an obstructive lesion at the vesical orifice and with a slightly contracted bladder.

The graph is shown in figure 2. An ideal adjustment of the catheter was made while the bladder was empty, so that respiratory waves were recorded. The pressure in the empty bladder was between 1 and 2 cm. of water. Fluid was introduced in equal amounts of 50 cc. until filling was complete. The intravesical pressure fell quickly to a resting level. Following the introduction of the first quantity of fluid the pressure was from 3 to 4 cm. and was 8 cm. only after 250 cc. had been injected. When the bladder contained 150 cc. and again at 200 cc. there were irregularities in the graph resulting from movement on the part of the patient; with 200 cc. in the bladder there was the first feeling of distention. As filling progressed the bladder accommodated an increased volume less quickly. After 300 cc. had entered the bladder the pressure fell slowly. There were a number of small waves of contraction, the pressure rose rapidly to 70 cm., and fluid escaped around the catheter. We felt that this was a normal record except that the total volume was somewhat below the average. A series of readings on normal individuals with bladder capacity of from 500 to 550 cc. has been made.

TYPES OF LESIONS OF THE NERVOUS SYSTEM

In figure 3 we have endeavored to give a suggestion of the position of the lesions discussed in this paper. The bladder is bilaterally represented in the cerebral motor cortex. Patients were chosen with bilateral cerebral accidents that injured the motor pathways on both sides; the lesion would correspond to an injury at a level marked 1. Also patients with unilateral lesions were studied; the injury would correspond to the section of one pathway at 2. The changes in the extremities of the latter patients were manifested as a hemiplegia. The other motor pathway arises from cells in the region of the midbrain; they apparently have to do with the control of tone in the smooth muscle of the bladder wall. The manner in which the tracts from these two regions make connections in the

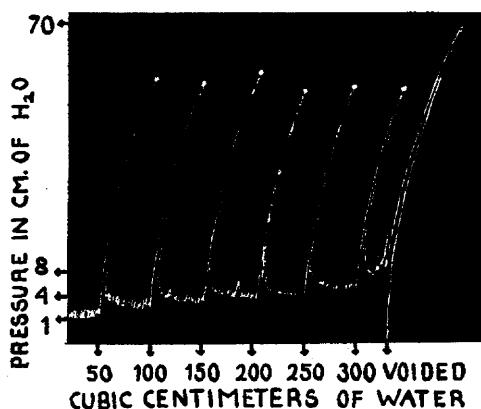


Fig. 2.—Normal cystometric reading.

cord to influence the preganglionic autonomic cells is little understood. The final group of abnormalities that we shall discuss have to do with lesions of the motor tracts in the spinal cord. Here the two motor tracts lie close together in the lateral columns of the cord.

BILATERAL LESIONS OF THE CEREBRAL MOTOR CORTEX OR OF THE INTERNAL CAPSULE

After bilateral lesions of the cerebral motor cortex or of the internal capsule, injuring the fibers running from the cortex to the spinal cord, characteristic

changes of the functioning of the bladder occur. The possible position of the lesion is indicated as 1 in figure 3. Under these conditions the bladder empties frequently and precipitously when small amounts of urine collect.

Usually the patient has little voluntary control and is constantly incontinent. If the sensory fibers to the cortex are uninjured, the patient may be aware of the imminence of micturition.

CASE 1.—A white man, aged 64, was diagnosed as having syphilis, bilateral hemiplegia, pseudobulbar palsy and bladder and bowel incontinence of five months' duration.

The record of the cystometric reading is shown in figure 4. The resting pressure in the bladder was 2 cm. of water. After 25 cc. of fluid had been introduced the pressure gradually fell to a resting level of 6.5 cm. Respiratory waves were recorded. Then the volume of the bladder was increased to a total of 50 cc. A cough occurred, which caused a sudden change of pressure. There was delayed accommodation. Then a wave of contraction occurred, followed by a fall of pressure and a sudden, precipitous rise to 96 cm. The bladder emptied completely around the catheter.

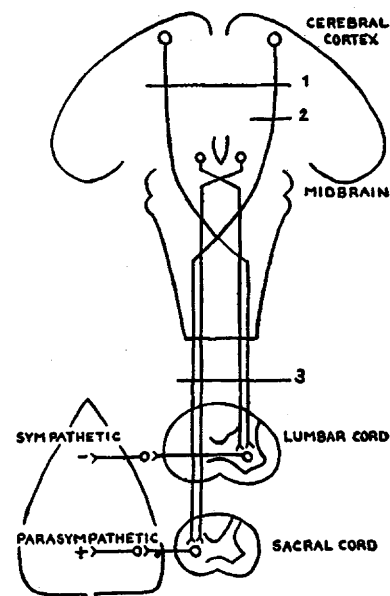


Fig. 3.—Position of lesions.

The average normal capacity of the human bladder is about 500 cc. In this patient the bladder contracted forcibly and emptied with a volume of 50 cc.

CASE 2.—A white man, aged 51, was admitted to the hospital in 1935. The diagnosis was bilateral hemiplegia, pseudobulbar palsy, and bladder and bowel incontinence.

Figure 5 shows the behavior of the bladder as twelve equal amounts of fluid of 25 cc. were introduced; a total amount of 300 cc. of fluid was used. The rises in pressure due to the addition of fluid are marked with white dots in order to increase the ease of reading the graph. Immediately after 75, 125, 175, 225 and 300 cc. were introduced, a contraction of the bladder musculature occurred. Some fluid escaped around the catheter at each rise of pressure, although the bladder did not empty completely. These contractions were of greatest force early in the process of filling, and they decreased in amplitude as a greater volume was attained.

The rises show that the muscle was hyperirritable to stretch stimuli. Contractions occurred only as every other 25 cc. of fluid was added.

UNILATERAL LESIONS OF THE CEREBRAL MOTOR CORTEX OR OF THE INTERNAL CAPSULE

In the basic work dealing with acute experiments with animals it was found that removal of one cerebral motor cortex caused a marked decrease in bladder volume.² Removal of both cerebral cortices produced a further decrease in bladder volume; the bladder then behaved after the manner described in the preceding section. Later the cerebral motor cortices were stimulated and the behavior of the bladder was noted.¹ This stimulation produced a fall in intravesical pressure followed by a sharp rise initiating micturition, if stimu-

lation was continued. We found that responses could be obtained more easily from one cortex than the other, and that usually the left was the more responsive. It was suggested that one cortex was dominant in bladder control.

We have studied the behavior of the bladder in seventeen persons with unilateral lesions of the cerebral motor cortex or internal capsule, with the typical changes in the extremities characteristic of hemiplegia.

Many of these patients did not complain of subjective bladder disturbance. In all cases the graph showed signs of abnormality. Six of these suffered from a left and eleven from a right hemiplegia. All six patients with a left hemiplegia had a bladder of approximately average volume.

Ten of the eleven patients who suffered from a right hemiplegia had a bladder of less than the normal capacity.

These observations suggest that

one hemisphere is dominant in bladder control, and that this dominance is on the left side in right handed persons.

CASE 3.—A Negro, aged 50, in August 1929 developed typical left hemiplegia with characteristic posture of the arm and leg.

A graphic record of the bladder function is shown in figure 6. Six equal quantities of fluid of 50 cc. were introduced into the bladder, which emptied on 300 cc. of fluid. The initial pressure in the empty bladder was 6 cm. of water, and the pressure remained below the level of 14 cm. of water until the bladder held 300 cc. Even with the viscus empty, and during the entire process of filling, small rhythmic contraction waves

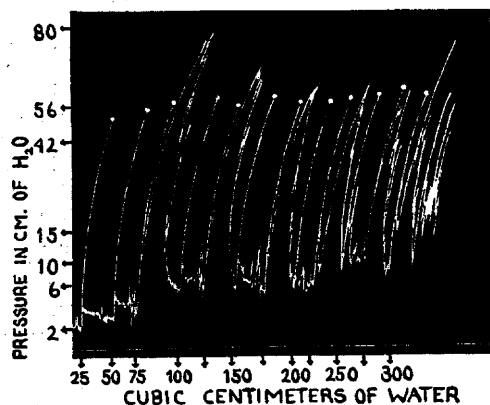


Fig. 5.—Behavior of bladder in case 2.

occurred. These have never been observed in the normal person. After the introduction of a quantity of fluid the pressure was slow in reaching a resting level; this became more marked as filling progressed. The rise of pressure at the end was definitely related to the introduction of fluid. Waves developed, which rapidly fused into a tonic contraction, emptying the bladder. This is a typical illustration of the type of graph

obtained from patients with a left hemiplegia. The total volume, however, was comparatively small.

CASE 4.—A Negro, aged 42, suddenly developed right hemiplegia with aphasia in October 1927.

The record of vesical function in this patient is shown in figure 7. Fluid was added in four equal quantities of 50 cc. Even with the bladder empty, contraction waves were present. They occurred throughout the course of filling, and the fall to a resting pressure was delayed after fluid was introduced. The pressure rose rapidly on 200 cc. of fluid, and the bladder emptied.

CASE 5.—A Negro, aged 43, lost the use of his right arm and leg in June 1934. A marked aphasia developed at the same time.

Study of the bladder revealed marked motor abnormalities, which are shown in figure 8. These have to do particularly with increased response to stretch stimuli. The pressure in the empty bladder was from 3 to 4 cm. of water; respiratory waves were recorded. After the first 50 cc. was introduced, the pressure fell slowly to a resting level of 6 cm. and there were small, irregular waves of contraction. Immediately following the introduction of each of the next three 50 cc. of water, the pressure rose to 76 cm. and sustained this level for some time. Irregularities of pressure were seen throughout the graph. Some urine was expelled with the strong contractions, but the bladder did not empty completely. When the bladder contained 200 cc. it contracted strongly not only once but a second time, and the experiment was terminated.

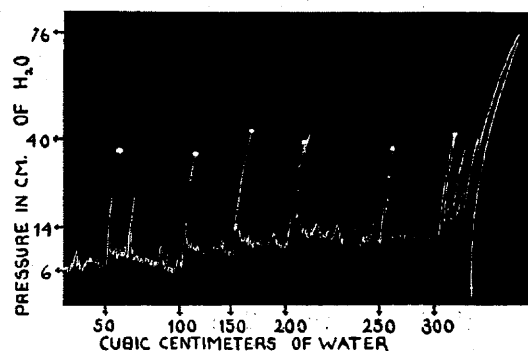


Fig. 6.—Function of bladder in case 3.

BEHAVIOR OF THE BLADDER AFTER INJURY OF THE MOTOR PATHWAYS IN THE SPINAL CORD

No cases of bilateral injury of the pathways arising in the midbrain that influence the activity of the bladder musculature have yet been recognized in isolated form. The pathway from the midbrain must lie close to the corticospinal pathway in the lateral columns of the cord, and the two may be injured together. We shall present examples of spinal cord injury which produce abnormalities corresponding to those described in the preceding section. Later other examples will be given in which we feel that both the corticospinal tracts and the pathways from the midbrain had been injured bilaterally.

CASE 6.—A Negro, aged 43, developed paraplegia in extension three years ago. This is a case of disseminated sclerosis. He never complained of any urinary symptoms. He stated that he micturated two or three times a day and twice at night.

Examination of the bladder function showed marked hyperactivity of the stretch reflex, as shown in figure 9. Fluid was introduced into the bladder in four equal quantities of 50 cc. The graph of the bladder recorded small waves of contraction. After each quantity of fluid was introduced, the pressure rose rapidly to over 65 cm. of water, and almost complete evacuation occurred with each rise. This is an excellent example of abnormality due to bilateral involvement of the corticospinal fibers to the bladder.

Another example of similar nature is given in which the bladder did not respond to each addition of fluid, and contractions due to more complicated causes were observed:

CASE 7.—A white woman, aged 39, suffered from disseminated sclerosis. In 1924 her legs became weak, and a year later she noticed decreased visual acuity. In 1925 she first developed frequency and urgency of micturition, and this has been one of the most unpleasant symptoms of the disease, as she had to empty the bladder almost hourly during the day and night. Report of the neurologic examination will be omitted except for the difficulties in the legs. The patient walked unsteadily on a broad base. There was outspoken ataxia of both legs. The deep reflexes were hyperactive in the legs, and there was a bilateral Babinski reflex. The blood and spinal fluid Wassermann reaction was negative.

The bladder record is shown in figure 10. Small contraction waves were seen with the bladder empty, and throughout filling. The pressure with the viscus empty was 5 cm. of water. The pressure fell to a level of 6 cm. after the first 25 cc. of fluid had entered the bladder. Then a sharp rise occurred to a pressure of 68 cm. without the escape of fluid. We believe that this rise was dependent on psychic stimulation. The door was suddenly opened and some one spoke in a loud voice. We have shown in another place that the corticospinal responses

are sometimes not entirely lost in patients with the bladder symptoms characteristic of disseminated sclerosis, and that the intravesical pressure may be either raised or lowered by psychic stimuli.³ The pressure remained low after the next two quantities of 25 cc. were introduced, but when the volume was made 100 cc. it rose to 70 cm. and the patient voided 75 cc., leaving a residual amount of 25 cc. The pressure fell to a resting level. Then no rise in pressure occurred until 75 cc. had entered

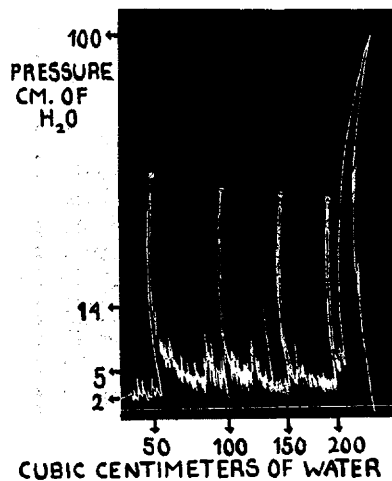


Fig. 7.—Vesical function in case 4.

the bladder, making a total of 100 cc. Again the pressure rose to the former high level and 75 cc. was voided. It may be assumed in this case that the stretch reflex became active on a volume of 100 cc.

In the next two patients there was a different type of contraction wave with filling:

CASE 8.—A Negro, aged 39, developed spastic paraplegia in 1925 due to syphilis. The patient complained of incontinence. This consisted of extreme urgency so that it was impossible to hold any quantity of urine, and dribbling occurred.

The bladder study is graphically represented in figure 11. Rhythmic waves were present even with the bladder empty. The introduction of 50 cc. of fluid was followed immediately by two large waves. The pressure then fell to a high resting level, and small contractions occurred at intervals. The patient was conscious of fullness during the large waves but was comfortable after they subsided. Increasing the volume of the bladder to 100 cc. is recorded on the graph by the second white dot. Then repeated large contraction waves occurred and the pressure never fell to a resting level. By engaging the patient in conversation we postponed the onset of the seventh wave. There was discomfort when the pressure was high. The waves continued with 150 cc. in the bladder, with moderate to severe discomfort. Some fluid escaped at the peak of the waves. With 200 cc. of fluid in the bladder the patient experienced severe pain. He could not voluntarily raise the pressure to a high level. The experiment was terminated at this point.

This record differs from the others in that the bladder was not only hyperirritable to stretch but rhythmic waves of contraction occurred continuously. These waves were relatively inefficient in discharging urine. There was little sensory involvement in the legs. We believe that in this case both of the motor pathways from the brain were interrupted bilaterally.

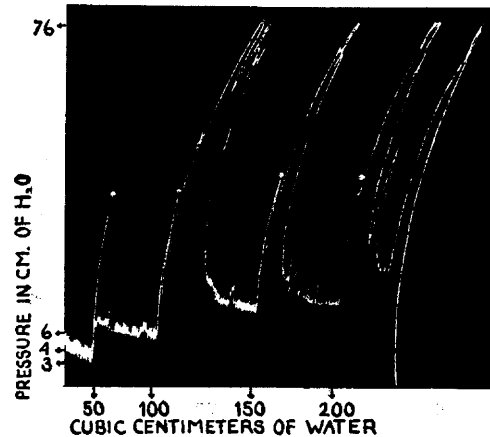


Fig. 8.—Motor abnormalities shown in case 5.

CASE 9.—A white man, aged 54, first noticed some weakness of both legs in 1932. Two years earlier he had developed frequency of micturition. In 1932 he suddenly became unable to void and since that time has used a catheter daily. There was slight spasticity of the legs. His gait was both spastic and ataxic, and the Romberg test was positive. Pain responses were poor in the ankles. The vibratory sense and sense of passive movement were unimpaired. There was a bilateral Babinski reflex and bilateral ankle clonus. The Wassermann test was negative in the blood and spinal fluid.

Figure 12 shows the filling record in this case. The pressure remained low until the volume was 150 cc. Then contraction waves appeared not only related to the introduction of fluid but also occurring rhythmically. They became more marked after the capacity reached 250 cc. The patient was very uncomfortable with 400 cc. in the bladder, and the waves were of great height. He was then asked to attempt to micturate and raised the pressure to 115 cm.; fluid escaped from the bladder. The frequent waves during filling with no sustained rises of pressure suggest an injury of both motor pathways from the brain.

COMMENT

The graphic method of recording vesical activity through an air-water system gives a clear picture of contraction waves during filling. These waves are not present in normal individuals, and their study is of importance in estimating the degree of loss of function. Normal micturition depends on a steady rise of bladder pressure of sufficient strength and duration to empty the viscus completely. When waves occur rhythmically and frequently, they do not have the strength or duration for efficient emptying. There may be some escape

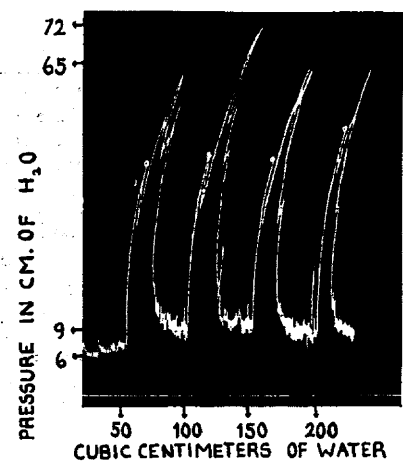


Fig. 9.—Marked hyperactivity of stretch reflex shown in case 6.

of fluid at the height of the waves. As the neurologic control of the bladder is progressively lost, the waves become more frequent but their force and duration become smaller.

The cases reported are typical examples of a large group of patients who were studied. The first group recorded bladder activity after removal of all motor

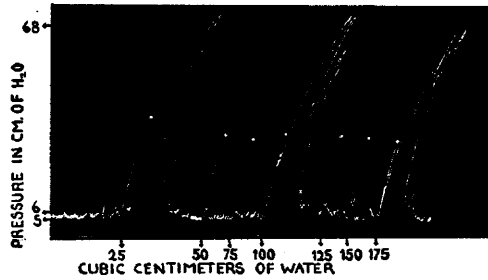


Fig. 10.—Bladder record in case 7.

stimuli from the cerebral cortices. Just as in striated muscle, so in the case of the smooth muscle of the bladder the cerebral cortex controls activity. It enables the bladder to hold large amounts of fluid at a relatively low pressure below the level of discomfort. After the removal of this influence the bladder capacity becomes smaller, and there is frequency of micturition.

The effect of loss of this cortical control can best be expressed in another way as a hyperirritability of the stretch reflex. Again an analogy with striated muscle can be used. The tone and to a certain extent the contraction of striated muscle is dependent on afferent stimuli, arising in the muscle itself. This is exemplified by the knee jerk. The sudden stretch applied to the tendon of the quadratus femoris stimulates the sensory endings in the muscle and produces a reflex contraction. These stretch reflexes are normally controlled by the cerebral motor cortex, and the deep reflexes become hyperactive after injury of the corticospinal fibers.

Denny-Brown and Robertson⁴ showed clearly that the smooth muscle of the bladder also responded to the stretch, and its activity was built up primarily on the basis of the stretch reflex. It is only necessary to

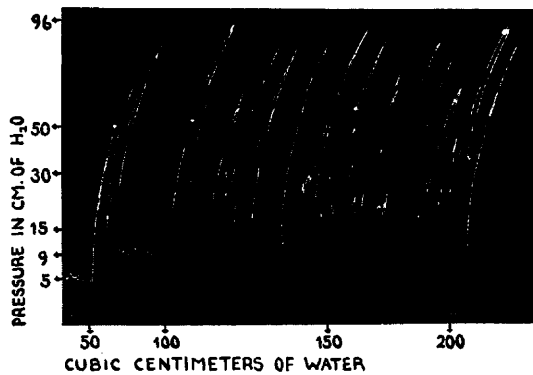


Fig. 11.—Bladder study in case 8.

examine the graphs in this paper to realize that the stretch reflex in the smooth muscle of the bladder is hyperactive after loss of cortical stimuli. Immediately after the introduction of fluid a strong contraction of

the muscle occurs, which is dependent on the sudden stretch produced by the fluid. This rise does not occur in a normal person, at least till the end of filling.

After injury of the corticospinal fibers, even on one side, similar increase in the stretch reflex is often seen. This is particularly true with lesions of the left side of the brain producing a right hemiplegia. It may be concluded that one hemisphere is normally dominant in the control of vesical activity.

The rapid and forceful rise of pressure dependent on the hyperactivity of the stretch reflex demands an immediate emptying of the bladder and gives rise to the complaint of urgency. As the normal cortical control is no longer present, these patients are unable to overcome the waves of contraction and cannot postpone micturition by a conscious effort. If the force of the waves is less marked, the urgency is less severe.

The frequency of micturition with the expulsion of a small volume of urine is dependent to a great extent on this hyperactivity of the stretch reflex. It is largely a physiologic abnormality and is not dependent on fundamental anatomic changes making the bladder small. This is evident from the fact that the patients often notice frequency only on some days, while on other days the bladder will hold a normal quantity. Excitement may at times give rise to frequency in the normal person.

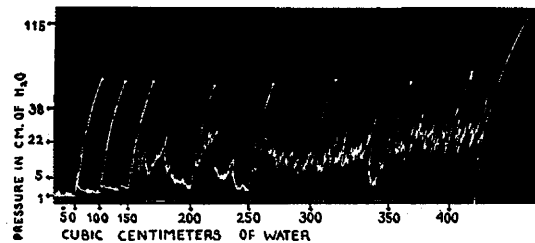


Fig. 12.—Filling record in case 9.

There is, however, another factor that undoubtedly contributes to the small quantity of urine which these abnormal bladders hold. After section of the corticospinal fibers there is increased tone of the striated muscle. This again is dependent on the hyperactivity of the stretch reflex. The increase in tone is more difficult to demonstrate in the case of the bladder. If the pressure falls to a resting level, it seems little higher than the resting level in a normal bladder. In some cases, however, the pressure during filling was high even at a resting level. It is probable that the small volume is dependent on the increased tone of the smooth muscle of the bladder wall decreasing the lumen of the viscus.

In all these patients with bilateral or even unilateral lesions of the corticospinal tracts the external sphincter showed increased tone. Denny-Brown and Robertson⁴ have suggested that this is dependent on an increased tone of the striated muscle entering into the composition of the external sphincter. This is not an all inclusive explanation, as the external sphincter has marked tone in patients with tabes. In these patients the striated muscle shows loss of tone.

When the interior of the hyperirritable bladder is examined with a cystoscope, coarse trabeculations of the detrusor are seen and the trigon shows hypertrophy. Whether this is due to actual increase in muscle volume or to thickening of the wall dependent on its small size it is difficult to say.

4. Denny-Brown, D. E., and Robertson, E. G.: On the Physiology of Micturition, *Brain* 56: 149 (July) 1933; The State of the Bladder and Its Sphincters in Complete Transverse Lesions of the Spinal Cord and Cauda Equina, *ibid.* 56: 397 (Dec.) 1933.

It is thought that the pathway from the midbrain influencing the bladder has to do with the control of tone in the wall. This mechanism is released from cortical influence and permitted to overact after bilateral injury of the corticospinal path. We have not recognized a case in which this mechanism was injured bilaterally without involvement of the corticospinal fibers. Theoretically this would produce an enlargement of the bladder with difficulty in emptying.

If these midbrain pathways are injured in the cord together with the adjacent corticospinal fibers, one would expect that bladder function would be less efficient. The waves of contraction, while occurring more often, are not of sufficient strength or duration to permit efficient emptying of the bladder. Fluid escapes from the urethra at the height of the waves, and the patient has little if any voluntary control, because of interruption of the corticospinal fibers. We have presented graphic records from two cases that fall into this group.

Rose⁵ has done a great service in popularizing cystometry among urologists. Recent workers⁶ have spoken of hypotonic and hypertonic bladders. This is perhaps a convenient classification, but it does not explain all possibilities of bladder abnormality. A hypotonic bladder may be one produced by injury of the posterior spinal roots in *tabes dorsalis*. Here, owing to overdistention and loss of tone, the bladder is able to accommodate large amounts of fluid at a relatively low pressure. We have been able to produce this condition experimentally and follow its evolution.⁷ The bladder would also be hypotonic immediately after a severe injury to the spinal cord, as the result of the so-called shock resulting from sudden interruption of pathways in the cord. Later with the development of reflex micturition it would be considered hypertonic. It has been shown that the bladder of small capacity after bilateral pyramidal tract injury is probably a hypertonic bladder in the true sense of the word. Here the resting pressure in the bladder is usually greater than normal. Of more importance than the resting pressure is the powerful, sudden contraction of the bladder that follows stretching of the muscle.

SUMMARY

By means of an air-water manometer and recording tambour we have made graphic records of the behavior of the detrusor muscle during bladder filling. The bladder muscle characteristically responds to stretch stimuli, and important information can be obtained by observing and recording waves of bladder contraction. Patients were studied who suffered either bilateral or unilateral pyramidal tract injuries or had lesions of motor tracts in the spinal cord. With release from cortical control, the stretch reflex is hyperactive. The bladder empties precipitously with a small volume of fluid. When the motor pathways from the midbrain are injured bilaterally along with the corticospinal tracts, the waves of bladder contraction are frequent but of small amplitude. They are ineffective in emptying the bladder. A study of contraction waves of the muscle during filling is of aid in forming an opinion of the efficiency of a bladder with damaged innervation.

Medical Arts Building.

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6. Muschat, Maurice: The Value of Cystometry, *J. Urol.* **33**: 366 (April) 1935.

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ABSTRACT OF DISCUSSION

DR. JOHN DUFF, New York: I congratulate the authors on their skillful use of cystometry in arriving at conclusions as to basic neurologic control of the normal and abnormal function of the bladder. It would appear that cystometry is not used with sufficient frequency in urologic clinics as a means of differential diagnosis and research. The authors have drawn interesting parallelisms between spastic voluntary musculature and what one might term a spastic urinary bladder, both resulting from interruption of cortical control. The commonly known efferent nerve fibers to the urinary bladder are the autonomic, sympathetic and parasympathetic fibers. The well known fibers of the cerebrospinal system are the somatic fibers assembled in the pyramidal tracts. The authors have shown that the central somatic system seems to establish connection not only with the lower voluntary motor neurons but also with the peripheral autonomic system of the bladder. I believe it true that pathologic lesions interrupting the pyramidal tracts frequently involve other related structures of the central nervous system. It is possible that the bladder disturbance in involvement of the pyramidal tract could be due to damage to adjacent visceral pathways. One might suppose that such visceral pathways could arise subcortically. The further postulation as to tonic control of the bladder from the midbrain centers explains satisfactorily the diminution of bladder tonus in lesions of the cord, which are so widespread as to intercept pathways both from the cortex and midbrain. The idea of central antagonistic pathways to the urinary bladder, inhibitory from the cerebral cortex and tonic from the midbrain, is most interesting and significant. It should help further to clarify problems of bladder dysfunction in lesions of the central nervous system. The work of Barrington, Dennig, Muller, Learmonth, Denny-Brown and Robertson bears out many of the significant points of this paper.

DR. MAURICE MUSCHAT, Philadelphia: Studies of relationship of the nervous system to the urinary bladder are now abundant, but they always remained a laboratory procedure and of merely academic interest. It was Dr. Rose's great contribution to apply this work at the bedside and thus aid the clinician in diagnosing a neurogenic bladder. With the simplification of the cystometer, such bedside studies have become popular. By using a water manometer, one is able to note the slightest fluctuations in the tonus of the detrusor and to evaluate the variations noted. For the ordinary clinical work of the urologist, a water manometer is somewhat unhandy and unnecessary. I feel that a practicing urologist should not as yet enter into discussions of the complicated neurologic problems. This is still the work of the neurologist. By means of the cystometer one obtains three factors: the desire to void, the pressure curve and the maximal voluntary pressure. With a normal bladder the desire is to void from 150 to 250 cc. of urine, the pressure curve is gradually ascending and the maximal pressure is from 40 to 60 mm. In the hypertonic bladder the factors are altered: The desire to void is less than 150 cc. of urine, the curve is very acute, and the maximal voluntary pressure is more than 60 mm. In the hypotonic bladder it is just the opposite: The desire is to void more than 250 cc. of urine, the curve is flat and the maximal voluntary pressure is less than 40 mm. Alteration of at least two factors is characteristic for a neurogenic bladder. The authors did not stress strongly enough the fact of finding marked abnormalities of the bladder in cases in which there were no urinary complaints. This possibility must be borne in mind and bladder dysfunction as evidenced by the cystometer looked for in every case in which a central or a spinal lesion is suspected. A positive finding becomes of inestimable value in the diagnosis of such cases.

DR. IRVING SIMONS, New York: In my clinic we have been interested in a study of the function of the bladder in various diseases, including diseases of the central and autonomic nervous systems. Physiologically the bladder should be considered as made up of two organs: (1) a detrusor or bladder proper, the contraction of which is governed by the parasympathetic nerves, and (2) an inner lock or internal involuntary sphincter, the tonus of which is governed by the sympathetic nerves. Beyond this is a second or external lock composed of the external sphincter, assisted by the bulbocavernosi and other perineal muscles. Cystometry records data merely of the action of the

detrusor, and this gives an idea only of the force but does not take into consideration the resistance that this force has to overcome. I have devised an instrument which may be termed a sphincterometer, by means of which we have been able to measure the tonus of the internal as well as the external sphincter. Clinical reports on this instrument will appear in the near future. In order to use this sphincterometer, it was necessary to construct an instrument, the portable microcystometer, which will accurately inject any amount of fluid at any rate and pressure. It will measure the tension or pressure on the bag developed by such an injection, or, if a plain catheter is used, it will measure the pressure exerted on the fluid injected into a muscular organ, the bladder. This is recorded with the greatest accuracy, as it is equipped with a reservoir type manometer of U. S. Bureau of Standards specifications, with accurately calibrated scale. The instrument is equipped with a pressure tube or intermediary, the fluid and air capacity of which has been diminished to the lowest point possible for clinical use, by which reduction the errors of pressure have been minimized and the load of fluid to be lifted by the bladder has been diminished to a point that will ensure the greatest accuracy possible. In making cystometric observations we have used the fractional injection method advised by Rose, using as the unit injections of 50 cc., injecting these increments without undue force or haste, and recording the pressure of each increment immediately so as not to allow the detrusor to relax after its reception of the increment. It is of paramount importance that the sensory filling points, of desire to void, of pain and of severe pain, be accurately elicited by questioning the patient, as without them curves of pseudoneurogenic or nonneurogenic hypertonia and hypotonia cannot be accurately differentiated from true neurogenic hypertonia and hypotonia. We feel that the accuracy of this cystometer has allowed us to separate four groups from the normal instead of the two described previously. In our work we have substituted for the graphs of Rose a numerical record similar to that of recording a gold chloride report.

DR. WILLIAM BISHER, New York: In a series of cases studied by Dr. Simons and myself by the fractional method with the microcystometer we were able to define four distinct groups that varied from the normal. Particular attention was paid in eliciting the sensory points: desire to void, pain and severe pain. We charted our results without graphs, separating the pressure obtained at each increment of 50 cc. by a comma and each 250 cc. by a semicolon. In five separate series of cases the average results obtained were as follows: 1. True neurogenic hypertonia was found in spastic paraplegia and combined sclerosis. These patients have short records averaging four increments. All the sensory points are moved to the left. 2. In nonneurogenic hypertonia, consisting of cases of increased intracystic pressure in which no essential neuropathologic condition could be found, pressure develops rapidly, usually after 200 cc. of fluid has been introduced. Their sensory points are normally situated and the average length of their record is twelve increments. 3. Normal cases show gradual rise in intracystic pressure with a record of twelve increments. The sensory points were found in the fourth, eighth and tenth increments. 4. In nonneurogenic hypotonia, neuropathologic changes were excluded clinically and serologically. Cystometrically they masqueraded as true neurogenic hypotonia because of their low tension and the length of their record. Their sensory points, normally or nearly normally placed, distinguish them from the true neurogenic hypotonia. 5. True neurogenic hypotonia was found in a series of cases of tabes and tabes with dementia paralytica. They have very long records with an average of twenty increments. All sensory points are moved to the right.

DR. LLOYD G. LEWIS, Baltimore: I wish to emphasize the value of obtaining graphic records of cystometric studies. The cystometer should be sensitive enough to record accurately every change in vesical pressure, but the graphic record is of great importance for a comparison of curves and for reaching conclusions. With our simple apparatus we have been able to record variations in bladder pressure due to respiration, variations of tonicity of bladder musculature and fluctuations due

to hyperactive stretch reflex and straining pressures. It is obvious that only detrusor pressure can be determined by this instrument. Lesions of the motor pathways of the bladder in the brain and spinal cord may be studied satisfactorily by this type of apparatus. Dr. Simons' instrument may be well adapted to study of the vesical sphincters.

ARTIFICIAL FEVER THERAPY OF SYPHILIS

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Artificial fever therapy now occupies a commanding position in the management of neurosyphilis. During the eighteen years that has elapsed since the monumental researches of Wagner-Jauregg¹ in the malaria therapy of dementia paralytica, it has become more and more apparent that simple fever production is the one factor common to the great variety of infectious, chemical and physical agencies that have been employed as substitutes for malaria therapy. This observation has led to a diligent search for physical methods which would overcome the inconstancy and hazards that attend the production of artificial fever by infectious agents, such as malaria, rat-bite fever or relapsing fever. Experiments in fever production have been conducted with many physical modalities (hot baths, hot air, diathermy, radiothermy and electric blankets). While comparable clinical results may be obtained with any of these methods, it has been recognized that many possess inherent hazards.

In a previous report,² the early results obtained in the pyretotherapy of neurosyphilis were described. Ultra-high frequency electric currents (10,000,000 cycles, 30-meter waves) applied by means of condenser discharges of a modified short wave radio transmitter, developed by Whitney,³ Page⁴ and De Walt,⁵ were applied in an air-conditioned cabinet, developed with the collaboration of Mr. Charles F. Kettering and Mr. Edwin C. Sittler of the Research Laboratories of the General Motors Corporation. The purpose of the air-conditioned cabinet was to dissipate sweat as it collected on the skin surface and thus to prevent arcing and burning of the skin as the result of concentration of the short radio waves in the drops of sweat.

Soon after this report was made, an accidental observation caused us greatly to alter the method of producing and maintaining artificial fever. While subjecting a child with congenital syphilis to artificial fever therapy by the combined radiotherm and air-conditioned

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Because of lack of space, this article is abbreviated in THE JOURNAL. The complete article appears in the author's reprints. A copy of the latter will be sent by the author on receipt of a stamped addressed envelope.

With the collaboration of Charles F. Kettering, Sc.D.; Edwin C. Sittler, B.S. in Engineering; Fred K. Kisligh, M.D. (deceased); H. Worley Kendall, M.D.; Arthur M. Culler, M.D.; L. G. Kauffman, M.D.; Eunice Frazer, M.S.; Carl McD. Ritter, B.S.; Florence Storck, R.N.; Mary Louise Wolf, R.N.; Ruth Walters, R.N., and Florence Buroker, R.N.

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