CHAPTER 12

Nocturnal Enuresis: the Importance of a Small Bladder Capacity

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Hallman (1950) was the first to measure functional bladder capacities, studying 63 enuretics and 129 normal children after water load tests. He noted that the functional maximum bladder capacity (MBC) of most enuretics was less than 330 ml, while that of most normal children was greater. His findings were confirmed by Muellner (1960), Vulliamy (1956) and Starfield (1967). Starfield's studies were much the most comprehensive, for she studied 221 enuretic children as well as 203 non-enuretic siblings. She demonstrated conclusively that the mean MBCs of enuretics are significantly smaller than those of their non-enuretic siblings. She also showed that children with secondary enuresis have small MBCs and, in this respect, resemble primary enuretics.

Esperanca and Gerrard (1969*a*) studied not only functional bladder capacities but also the frequency with which urine is passed by normal and enuretic children. They confirmed that enuretics, on average, have small MBCs, and also demonstrated that they tend to pass urine more frequently during the daytime than do normals. These studies indicated that, although the prime problem of the enuretic is bed-wetting, his main disability, namely the small capacity bladder, is present during the daytime as well, and unless he reduces his fluid intake he also has frequency.

Measuring Bladder Capacities

There are two simple ways of measuring the maximum functional bladder capacity (MBC). The first is to give an oral water load equivalent to 30 ml/kg body weight (maximum volume 500 ml), and to ask the child to refrain from voiding until he or she is in real discomfort. The first two voided specimens are measured; the larger of the two is taken as the MBC. A second method is to provide a parent of the child, usually the mother, with a measuring cylinder, and to ask her to record and measure all specimens of urine passed during the course of a week; if the child is at school, specimens passed during school hours will not be recorded. The largest volume of urine passed is taken as indicating the MBC.

In our initial studies, we compared the MBCs obtained following a water load test and those obtained by measuring volumes passed during the course of a week. The volumes obtained by the latter method were greater than those obtained by the water load test, and for this reason we have adhered to the latter form of study.

The water load test yields smaller MBCs, we believe, because in this test the bladder is filled comparatively quickly, and has less time to accommodate to the increasing volume of urine. Our studies have also shown that some normal children have

unexpectedly capacious bladders, their MBCs being 800-900 ml, and need to pass urine only once or twice a day. Such children do not experience discomfort after a water load test, unless they have a comparatively full bladder to begin with. Consequently, they may be tempted to pass urine before experiencing discomfort, in order to complete the test and go home.

When parents are prepared to measure and record volumes of urine passed at home, two additional pieces of information are obtained, namely, the average amount of urine passed at a time, and the frequency with which the child voids. Recently, we have asked parents to carry out these studies not only on their enuretic but also on their non-enuretic children (if they have any). In this way, apart from obtaining additional information on normals, we have been able to demonstrate to the parents how markedly their enuretic children differ from their normal siblings in respect of their pattern of micturition.

Maximum Functional Bladder Capacities in Normals, Enuretics, and Girls with Recurrent Urinary Infections

The present studies were carried out on 223 normal children (98 boys and 125 girls) aged four to fourteen years, on 75 enuretics (52 boys and 23 girls) aged four to fourteen years, and on 89 girls with recurrent urinary infections aged three to thirteen years.

The mean MBCs of the normal and enuretic children are illustrated in Figure 1. Although no significant difference was found between the control and the enuretic children in any specific age range, the mean MBCs of the two groups, after adjustment to account for disparities with regard to the proportion of individuals from each group within a particular age range, were highly significantly different ($p < 0{\cdot}0005$). Although most of the enuretics had MBCs which were appreciably smaller than those

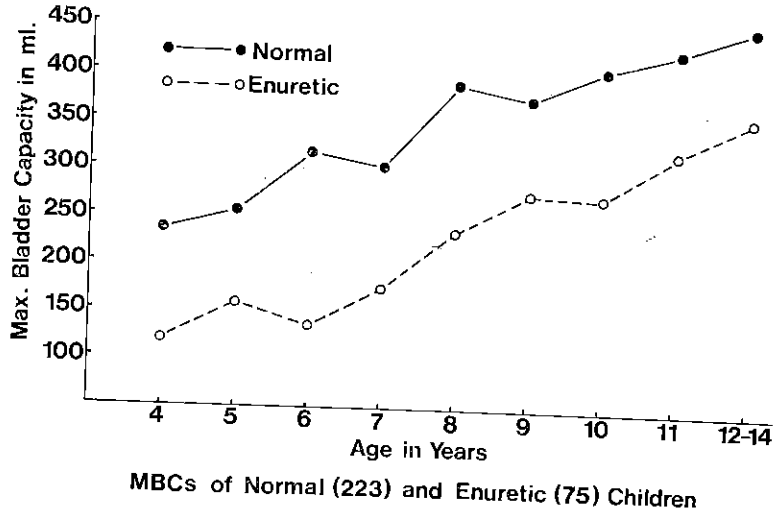


Fig. 1. Mean maximum functional bladder capacities in normal children (n = 223) and in enuretics (n = 75).

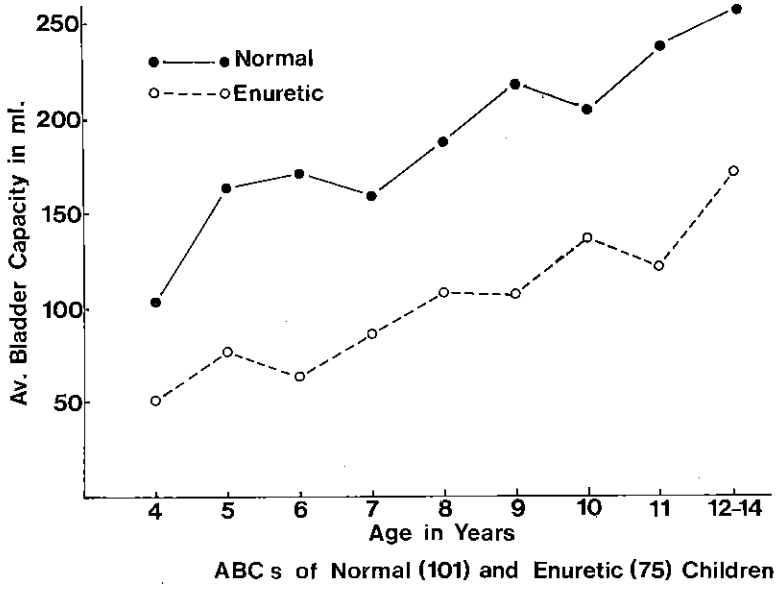


Fig. 2. The average amount of urine passed at each voiding by normal children (n = 101) and by enuretics (n = 75).

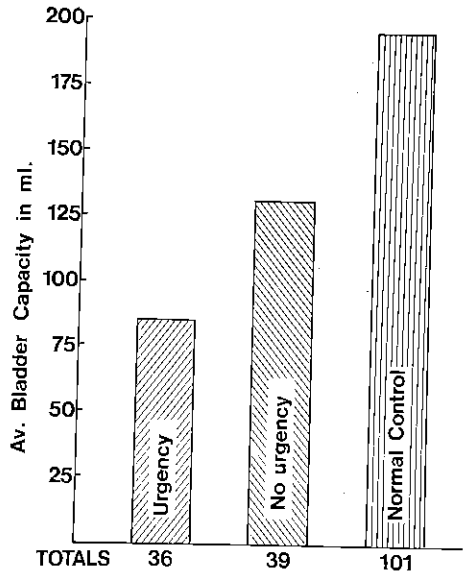
of the normal children, 18 (24 per cent) of the enuretics had MBCs within what we would consider the normal range.

Figure 2 shows the mean average functional bladder capacities (ABCs) of the normals and of the enuretics. Again it can be seen that the enuretics passed, on average, smaller amounts of urine than did the normals; the difference between the adjusted means is again significant ($p < 0{\cdot}0005$).

Thirty-six (48 per cent) of the enuretics under study had urgency, and 20 (27 per cent) had day dribbling or diurnal enuresis. The adjusted mean ABCs of both these groups were significantly smaller ($p < 0{\cdot}0005$) than those of the enuretic children free from either urgency or day dribbling (Figs. 3 and 4).

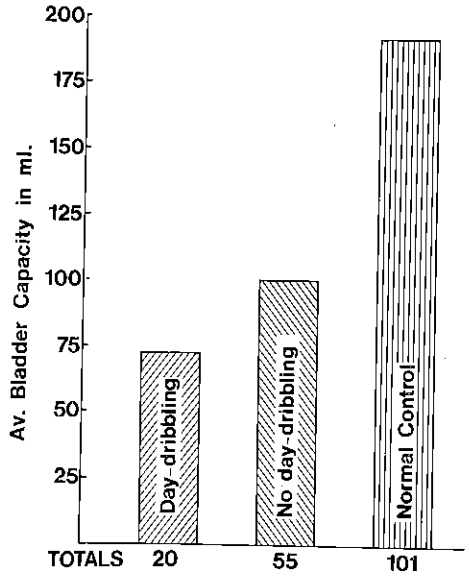
Children with recurrent urinary infections are not infrequently enuretic, and, although our study of MBCs in children with recurrent urinary infections was embarked on as part of an unrelated project (Jones *et al.* 1973), the findings are relevant to this report. The studies were carried out in 89 girls, after the urinary infection had been eradicated, and at a time when the urine was normal. Fifty-six (63 per cent) had had nocturnal enuresis when first studied, of whom 48 had small MBCs. The children who had not been enuretic had normal MBCs. The findings are illustrated in Figure 5. The difference between the mean MBCs of the two groups, after adjustment of the means to account for disparities with regard to the proportion of individuals from each group within a specific age range, is highly significant ($p < 0{\cdot}001$).

Of the 56 children who had had enuresis, 40 remained enuretic after being cured of the urinary infection. The enuresis in these children was therefore almost certainly not due primarily to the urinary infection. The high incidence of persisting enuresis



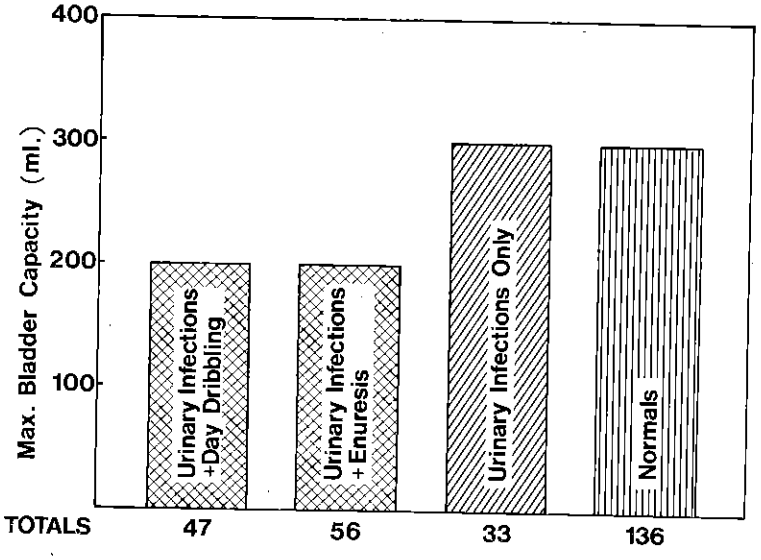
ENURETICS. Adjusted Mean Bladder Capacity

Fig. 3. Adjusted mean average bladder capacities of normal children and of enuretics with and of enuretics without urgency.



ENURETICS. Adjusted Mean Bladder Capacity

Fig. 4. Adjusted mean average bladder capacities of normal children and of enuretics with and of enuretics without day dribbling (diurnal enuresis)



Maximal bladder capacities, means adjusted for age and numbers

Fig. 5. Adjusted mean maximum bladder capacities of normal children, girls with urinary infections and no enuresis, girls with urinary infections and nocturnal enuresis, and girls with urinary infections associated with enuresis and day dribbling (diurnal enuresis).

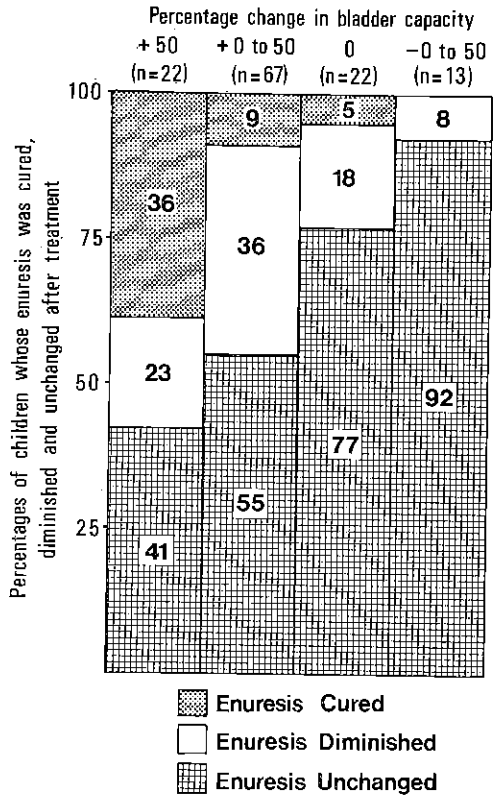


Fig. 6. Response of maximum bladder capacity to treatment; the greater the increase in bladder capacity, the more likely the child is to become dry.*

in girls with recurrent urinary infections (40 out of 89 in this series, compared with an expected incidence of only 9 out of 89 in an age-matched sample of normal girls) indicates that the association between enuresis and recurrent urinary infections is not a chance one ($p < 0{\cdot}001$). Thus, it appears that, in girls, enuresis is more likely to predispose to the development of recurrent urinary infection than the reverse.

Functional Bladder Capacities in Children Whose Enuresis has been Cured

We have usually treated enuresis either by the elimination of certain common foods, or by the administration of imipramine, or by both. Our initial studies (Esperanca and Gerrard 1969*b*) indicated that, with management on these lines, the enuretic who recovered also developed a normal MBC. The present studies have confirmed these findings. It can be seen from Figure 6 that the highest proportion of cures occurred in the group with the greatest increase in the bladder capacity*. Children in this group with very small initial ABCs (*i.e.* less than 100 ml) tended to remain enuretic on treatment, for, even after an appreciable increase in ABC, their bladder capacities remained smaller than normal.

*As several children received more than one form of treatment, and were studied on more than one occasion, the number of studies shown in Fig. 6 exceeds the number of children investigated.

It would appear that imipramine usually leads to bladder relaxation and an increase in bladder capacity through its anti-cholinergic properties. However, one child who recovered from his enuresis while being given imipramine did not exhibit any increase in bladder capacity; instead, he appeared to become more sensitive to stimuli emanating from the bladder, which woke him up at night and sent him to the toilet to pass urine—hence he became dry. MBCs have been studied in only one child treated with the 'bed buzzer'; this child became dry at night, and her MBC also increased appreciably.

Discussion and Conclusions

The data we have presented indicate that, in general, children with nocturnal enuresis

(1) have smaller maximum bladder capacities than non-enuretics,

(2) pass urine more frequently than non-enuretics, and

(3) have bladders which are only functionally and not structurally small.

These findings have recently been confirmed by Troup and Hodgson (1971), who studied 25 enuretic and 15 non-enuretic children aged between four and eleven years. All the children were admitted to hospital for the period of study, and were submitted to a complete examination, including intravenous pyelography, to exclude the possibility of organic urinary tract disease. Measurements were made over a 48-hour period of the number of times each child passed urine, and of the volume of urine passed on each occasion. In the case of the enuretics, these measurements were made both during the day and also, by an ingenious method, during the night. The enuretic children were also examined cystoscopically under light anaesthesia. It was thus possible to measure the bladder capacity at 40 cm water pressure under light anaesthesia.

The results showed that there was no difference between the two groups with respect to the total volume of urine passed at night or during a 24-hour period. However, the number of voidings per 24 hours was significantly higher, and the volume of urine passed per voiding act significantly lower, in the enuretic children. In other words, they had a smaller functional bladder capacity than the normal children. This difference was more marked in the children in the older age groups; for example, in the four to six years age group the difference in average functional bladder volume between the enuretic and the non-enuretic children was 45 ml, whereas in the nine to eleven years age group it was 180 ml. What was particularly interesting was the finding that under general anaesthesia the bladder volume of the enuretic children at 40 cm water pressure was comparable to that of normal children. This suggests that there is no intrinsic abnormality in the bladder itself which prevents it from accommodating normal quantities of urine.

The data we have presented here have shown also that (a) children with diurnal enuresis have functional bladder capacities even smaller than those of children with nocturnal enuresis, and (b) recovery from nocturnal or diurnal enuresis is nearly always associated with an appreciable increase in maximum functional bladder capacity, which usually becomes normal.

Children with recurrent urinary infections have been found to have a high incidence of enuresis, the enuresis again being associated with a small MBC. That enuresis and recurrent urinary infections are related was noted by Savage and his colleagues (1969) in their studies on asymptomatic bacteriuria in girls, and is apparent from the similar studies carried out by Meadow *et al.* (1969). More recently, Dodge *et al.* (1970) in a survey of 9411 six- to ten-year-old children, have noted that the incidence of enuresis is more than twice as high in bacteriuric as in non-bacteriuric girls. They found too that the more enuretic the child was (*i.e.* the more often the bed was wet each week), the more likely she was to have a urinary infection. We ourselves had always supposed that enuresis in a child with a urinary infection was symptomatic of the infection, but the finding that the enuresis usually persists after the cure of the infection, and also that it is associated with a small MBC, suggests that enuresis in girls may predispose to the development of urinary infections rather than the reverse.

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