Enuresis (from the Greek word "enourein", which means "to void urine") is involuntary urination. Enuresis that occurs only during the night is called “nocturnal enuresis” or, more commonly, “bedwetting.” Most children no longer wet the bed after 4 years old. However, for 15%–20% of 5-year-old children, bedwetting is problematic. Even with treatment, a child may continue to have enuresis. Why it can persist despite treatment has long perplexed scientists. However, some recent findings suggest that enuresis treatment itself, endocrine dysfunction, and other factors may contribute to the persistence of enuresis.

The third edition of the International Classification of Sleep Disorders by the American Academy of Sleep Medicine lists the following diagnostic criteria for enuresis:

1. The child is older than 5 years;
2. The child exhibits recurrent involuntary voiding during sleep at least twice weekly;
3. Involuntary voiding has been present for at least 3 months; and
4. The child had been consistently dry during sleep (i.e., a child has never been successfully trained to control urination).

For secondary nocturnal enuresis (i.e., enuresis that occurs because of another problem), a child must have all four of the following features:
1. The child is older than 5 years;
2. The child exhibits recurrent involuntary voiding during sleep at least twice weekly;
3. The child has involuntary voiding for at least 3 months; and
4. The child had been consistently dry during sleep for at least the previous 6 months (i.e., a child was previously able to control urination).

Problems that may result in enuresis are a stressful situation (e.g., parental divorce), sleep-disordered breathing (e.g., obstructive sleep apnea) or other sleep disorder, diabetes mellitus (i.e., type II diabetes) or diabetes insipidus (i.e., type I diabetes), infection, or epilepsy.

Scientists are not sure why enuresis occurs, but have proposed several theories. Richard Butler and Philip Holland propose the three-systems model. In this model, enuresis results from a dysfunction in one or more of the following three systems: (1) the nocturnal release of vasopressin (also called "antidiuretic hormone"); (2) bladder muscle activity; and/or (3) ability to arouse from sleep in response to bladder sensations. When these systems are not working correctly, the following can occur: an insufficient amount of vasopressin results in excessive nocturnal urine production [i.e., diuresis], which can then lead to enuresis; unstable activity of bladder muscles such as the detrusor muscle—which on contraction expels urine from the bladder—can result in enuresis; and an inability to arouse when the bladder is full allows a child to sleep through an episode of enuresis.

J. P. Guignard suggests that dysfunctional circadian release of vasopressin may be involved in enuresis. The urine flow rate normally increases during the daytime and decreases during the nighttime. This rhythm appears to be absent in some children with enuresis because they produce abnormally large volumes of dilute urine. Vasopressin normally causes the kidneys’ to resorb water from the urine, thereby concentrating urine and reducing its production (hence “antidiuretic”). Therefore, decreased amounts of vasopressin cause urine to become more dilute and the kidneys to release an increased amount of urine (i.e., diuresis).

Gabriella Aceto4 and colleagues suggest that low levels of adrenocorticotropin hormone in association with nocturnal hypercalciuria (i.e., excessive amount of calcium in the urine) has a role in nocturnal enuresis. (Adrenocorticotropin hormone causes the release of corticosteroid hormones such as cortisol and aldosterone that play a role in calcium metabolism.)

Because children with enuresis sleep through an episode, parents commonly believe that their child is sleeping “too soundly” to awaken and go to the toilet. Some research has therefore focused on determining whether children with enuresis are sleeping “more soundly” than children who do not have enuresis. The findings of some recent studies challenge this belief. In one polysomnographic study, the sleep of children with and without enuresis was compared. The researchers found no major differences between the two groups of children (i.e., the sleep of children with enuresis was normal). An actigraphy study similarly compared the sleep of children with and without enuresis, and found that the sleep of children with enuresis was significantly worse: the children with enuresis had a greater number of nocturnal awakenings. Another study demonstrated no major differences in the sleep of enuretic children during their “wet” nights and their “dry” nights.

In recent years, some research has demonstrated that children with enuresis have a higher incidence of periodic limb movements.
and cortical arousals, compared to children without enuresis.\(^5,9\) These phenomena result in more awakenings from sleep, thereby disrupting sleep and leading to poor sleep quality. Poor sleep quality may contribute to difficulty a child has in arousing from sleep during an episode of enuresis.

The most effective treatment for enuresis is lifestyle modification, followed (in order) by enuresis alarms, and drug therapy.\(^10\) Lifestyle modifications may involve restricting fluid intake in the evening, not allowing a child to ingest substances before bedtime that can have a diuretic effect (e.g., fruits such as watermelon or lemon and caffeine-containing foods such as chocolate and cocoa), having a child void regularly during the day, awakening a child to go to the toilet during a sleep period, and having a child void just before going to bed and on awakening in the morning.

When lifestyle changes do not reduce enuresis episodes, a physician may next try an enuresis alarm. The goal of the alarm is to condition a child to awaken in response to a full bladder. The alarm system has a moisture sensor that a child wears in his/her pajamas or underwear and an alarm. On sensing moisture, the sensor triggers the alarm. A child would ideally be awakened by the loud sound and get up to use the toilet. During early stage of using an enuresis alarm, a parent is usually awakened by the sound first and then awakens the child. With continued use, the child ultimately learns to awaken to the sound and get up to use the toilet.

If the enuresis alarm does not work, a physician may next try drug therapy. Some drugs that have been used to treat enuresis are desmopressin (a drug that simulates the actions of vasopressin), tolterodine or oxybutynin (both drugs decrease the activity of muscles involved in urination), and imipramine (a drug that reduces the amount of slow wave sleep [the sleep stage in which enuresis typically occurs, although enuresis can occur in all sleep stages]).

The success of treatment may be affected by many factors. For example, for an enuresis alarm to condition a child to awaken with an episode of enuresis, the child must be consistently be awakened when the alarm sounds. Without this consistency, treatment may fail. However, even with good compliance, the enuresis alarm may still fail because it involves awakening a child one or more times during a sleep period to urinate. If a child has an undiagnosed sleep disorder such as periodic limb movement or obstructive sleep apnea, the additional arousals may contribute to poor sleep quality and increased sleepiness that consequently may manifest as difficulty in awakening. Hence, a child may continue to sleep through enuresis episodes.

Another factor that may affect the success of treatment is that there may be different subtypes of enuresis. Providing a child the wrong treatment approach may allow enuresis episodes to persist. For example, some children respond very well to desmopressin (i.e., enuresis stops or is reduced), which indicates that these children are not producing sufficient levels of vasopressin during sleep.\(^1,11\) However, enuretic children with hypercalciuria may not respond as well to desmopressin therapy.\(^4,12\) Treatment for these children may instead involve dietary changes such as restricting the amount of calcium intake, reducing sodium intake, and avoiding foods (such as spinach and chard) containing a high level of oxalates, or involve the use of drugs such as thiazide diuretics that increase the reabsorption of calcium from urine. Giovanna Valenti\(^13\) and colleagues recently demonstrated that enuretic children with hypercalciuria responded well to dietary changes.

Enuresis is problematic for parents and increasingly becomes a problem for a child as the child ages. Children are often embarrassed about having enuresis, may be teased by peers about it, or may feel left out of activities their friends can enjoy such as sleepovers. Parents may similarly feel embarrassed in explaining to other parents that their child is a bedwetter or may feel frustrated because of having to change a child’s bedding frequently. Effective enuresis treatment can avoid these problems. Screening a child for low levels of vasopressin or for hypercalciuria, and treating accordingly, could improve the outcome of enuresis treatment. For now, scientists continue to investigate phenomena associated with enuresis (e.g., periodic limb movements, cortical arousals) to determine the extent they contribute to enuresis and/or impede treatment success in children with enuresis.

**REFERENCES**


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