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Original Article

Evaluation of nocturnal blood pressure changes and urinary electrolyte excretion in children with enuresis

Zeynep Şengül Emeksiz[1], Pınar Işık Ağras[2], Serhat Emeksiz[1], Yıldız Bilge Dallar[1]

Departments of [1]Pediatrics and [2]Pediatric Nephrology, Ministry of Health Ankara Training and Research Hospital, Ankara, Turkey.

ABSTRACT

Background. Monosymptomatic nocturnal enuresis (MNE) is defined as involuntary nighttime urination of children over five years of age without any congenital or acquired defect in the central nervous system. Many factors, mainly nocturnal polyuria, sleep disorders, decreased bladder capacity, and bladder dysfunctions play a role in the etiology of MNE.

Methods. Eighty-three children diagnosed with MNE were included in the study. Complete blood cell count, blood biochemistry, renin, and aldosterone levels of all children were obtained. Twenty-four-hour urine samples were collected separately daytime and nighttime and urinary electrolytes were evaluated. Also, 24-hour ambulatory blood pressure monitoring (ABPM) was performed for each patient. The results were evaluated by comparing both enuretic children vs. control group and enuretic children with polyuria vs. without polyuria.

Results. When we compared the enuretic children and the control group in terms of urinary electrolytes, the fractional excretion of sodium (FENa) and fractional excretion of potassium (FEK) values of the enuretic group were higher than the control. The evaluation of the 24-hour ABPM findings revealed no significant difference in terms of the mean arterial pressure (MAP) and diastolic blood pressure (DBP) during the daytime and nighttime measurements. The daytime systolic blood pressure (SBP), however, was significantly lower in the enuretic group. When enuretic children with and without polyuria and the control group were compared, the nighttime, FENa, FEK, as well as nighttime urinary excretion of calcium and protein were significantly higher in enuretic children with polyuria. No difference was detected on the MAP, SBP, or DBP values.

Conclusions. In conclusion, the nighttime urinary solute excretion of enuretic children was found to be higher and this condition may especially be associated with pathogenesis of nighttime polyuria. In enuretic children, nighttime blood pressure changes were not influential in the etiopathogenesis in all patient groups and multiple mechanisms may play a role in the pathogenesis of enuresis.

Key words: enuresis, ambulatory blood pressure, urinary electrolyte excretion.

Monosymptomatic nocturnal enuresis (MNE) is involuntary urination only during sleep which is not accompanied by any bladder symptoms and with completely normal daytime urination pattern. Its prevalence is about 10% in seven-year-olds and about 5% in 10-year-olds.[1,2]

Numerous factors influence the etiology of primary MNE. The least implicated among these factors are nocturnal polyuria, sleep disorders, decreased bladder capacity and bladder dysfunction. However, the same pathophysiological mechanisms do not apply to each patient and it is considered that different mechanisms could be responsible for different wet nights of the same patient.[2,3]

It is well established that sodium and potassium excretion of normal children present a diurnal rhythm and that excretion is reduced during

✉ Zeynep Şengül Emeksiz
drzeynep83@hotmail.com

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nighttime but this rhythm is impaired in enuretic children.[4] Increased solute excretion accompanying tubular reabsorption of water can also explain this situation. In the literature, there are studies suggesting that the pathogenesis of enuresis is affected by disturbances in distal renal tubules.[5]

In enuretic children; our knowledge on the relationship between nocturnal blood pressure changes and nocturnal polyuria is still limited. In this study, it is aimed to reveal the correlation between the daytime – nighttime blood pressure changes and electrolyte excretion in children with primary MNE.

Material and Methods

In this study; 83 children diagnosed with MNE were included. The control group was constituted by 62 patients with same age and gender characteristic. Children with MNE with minimum three wet nights a week were included in the patient group before any medical or behavioral treatment were started. The control group consisted of children who applied to outpatient clinics with complaints other than enuresis, including acute mild respiratory tract infection or for routine check-up.

Complete blood cell counts, biochemical parameters, renin and aldosterone levels of all children were worked on venous blood samples that were taken at 08:00 a.m. For determination of renin and aldosterone levels, RAI-DSL kit (Active® RIA DSL; Diagnostic Systems Laboratories, Inc., Webster, TX) was used. The samples were employed in the Ministry of Health Ankara Training and Research Hospital Biochemistry and Hematology laboratories.

During the following 24-hour following sampling, urine samples were collected separately in nighttime and daytime for evaluating sodium, potassium, creatinine, phosphorous, calcium and protein values.

For night time urine collection, the child was awakened once more than the usual nightly incontinence frequency, taken to the toilet and urine was collected for the whole night including the first morning urine sample.

FENa, FEK, tubular phosphorous reabsorption (TPR) was calculated with following formulae:

FENa (%) = [(urinary sodium / urinary creatinine) x (serum creatinine / serum sodium)] x 100

FEeK (%) = [(urinary potassium / urinary creatinine) x (serum creatinine / serum potassium)] x 100

TPR (%) = [(1- (urinary phosphorous / urinary creatinine) x (serum creatinine / serum phosphorous)] x 100

Urinary protein excretion was calculated as "mg/m²/h" while urinary calcium excretion was calculated as "mg/kg/day".

The bladder capacity of the enuretic children was calculated by the formula: 30 + [age (years) x 30] ml formula. Children with a nighttime urine volume exceeding 130% of the expecting bladder capacity were acknowledged as polyuric enuretic children. The results were compared in two stages: enuretic children vs. control group and enuretic children with/without polyuria vs. control group.

Simultaneously with urine collection, the ambulatory blood pressures of all children were measured with Mobil – O – Graph NG (I.E.M. GmbH, Germany) device at intervals of 15 minutes during daytime and 30 minutes on average during nighttime while children were conducting their normal daily activities. During ambulatory blood pressure measurement, sleeping and waking up times were recorded. Day and night time measurements were defined and evaluated according to these data. Blood pressure percentiles according to age, gender and height were used for evaluation of measurements.[6]

Written informed consent was obtained for each child included in the study. The study was approved by the Ethics Committee of Ministry

of Health Ankara Training and Research Hospital (no: 0398/2010).

Statistical analysis

The data obtained from this study were evaluated by means of SPSS 22 package software. Descriptive statistics were indicated as mean ± standard deviation (minimum – maximum) or as median (IQR, 25th–75th percentile) while nominal variables were indicated as observation count and (%). For double group comparisons Student's t-test, for triple group comparison Kruskall-Wallis test; for comparison of paired variables, the Wilcoxon tests were used. For correlation analysis, Pearson correlation analysis method was used. The significance level was accepted <0.05.

Results

Among 83 enuretic children, 33 (39.8%) were girls and 50 (60.2%) were boys with average age of 9.2 ± 2.6 years. In the control group, 32 children out of 62 (51.7%) were girls while 30 (48.35) were boys with an average age of 9.9 ± 2.2 years. In terms of age and gender, the children with enuresis were of similar characteristics with the control group (p>0.05).

Comparison of enuretic children with the control groups

When the results of complete blood cell count of patients were assessed, no significant difference (p>0.05) was found between the children with enuresis and the control group in terms of hemoglobin, white blood cell count and platelet counts. However, hematocrit values were lower in the control group (p<0.05).

Among biochemical parameters, urea, creatinine, albumin, sodium, potassium, calcium and phosphorous were evaluated. The values of phosphorous were determined to be lower in the control group (p<0.05). No significant difference in terms of other biochemical parameters was detected between two groups (p>0.05). There was no significant difference in terms of serum renin and aldosterone levels. (p>0.05) (Table I)

The mean nighttime urine volume of enuretic group was distinctively higher (1.1 ± 0.7 ml/kg/h) than control group (0.9 ± 0.5 ml/kg/h) (p<0.05). Daytime urine volumes were similar in both groups (Table II).

The mean FENa of the enuretic group, calculated in the nighttime urine samples was found to be significantly higher than that of

Table I. Laboratory findings of children included in the study.

Variables	Enuretic children (N=83)	Control group (N=62)	P value
Hemoglobin (gr/dl)	13.2 ± 0.9	12.9 ±1.2	>0.05
Hematocrit (%)	39.0 ± 2.7	37.7 ± 3.6	<0.05*
White blood cell count (/mm^3)	7938 ± 2864	7740 ± 2563	>0.05
Platelet count (/mm^3)	302,554 ± 82,209	286,916 ± 66,685	>0.05
Urea (mg/dl)	24.9 ± 7.3	25.1 ± 7.3	>0.05
Creatinine (mg/dl)	1.5 ± 0.2	0.6 ± 0.1	>0.05
Albumin (gr/dl)	4.5 ± 0.2	4.6 ± 0.4	>0.05
Sodium (mEq/L)	137.9 ± 13.8	139.3 ± 2.3	>0.05
Potassium(mEq/L)	4.4 ± 0.3	4.2 ± 0.6	>0.05
Calcium (mg/dl)	9.9±0.4	9.9 ± 0.4	>0.05
Phosphorus (mg/dl)	4.7±0.5	4.4 ± 0.6	<0.05*
Renin (pg/ml)	30.2 ± 18.5	25.7 ± 12.0	>0.05
Aldosterone (pg/ml)	211.3 ± 136.8	176.1 ± 129.0	>0.05

Data are presented as mean ± standard deviation.
*p <0.05

the control group (p<0.05). Yet there was no significant difference between enuretic children and control group regarding the mean FENa calculated in daytime urine samples (p>0.05) (Table II).

FEK value calculated in nighttime urine samples was higher in enuretic children compared to control group. No significant difference was determined regarding the daytime values of the same parameters (p>0.05). When comparing enuretic children with the control group in terms of daily urinary excretion of calcium and protein, no significant difference was determined (p> 0.05) (Table II).

TPR values were comparable between the two groups (p>0.05) (Table II).

Evaluation of ambulatory blood pressure values showed that daytime mean systolic blood pressure of enuretic children (104.1± 6.5 mm Hg) was lower compared to that of the control group (107.2± 8.4 mm Hg) (p<0.05). When systolic daytime blood pressure load was analyzed; enuretic children showed lower results (5.1± 5.9 mm Hg) than the control group (8.7± 10.1 mm Hg) (p<0.05). No significant difference was determined between the two groups in terms of other ambulatory blood pressure parameters (p>0.05; Table III).

Comparison of enuretic children with vs. without polyuria and control group

Children with polyuria had significantly higher mean FENa and FEK in nighttime urine samples (p <0.05); but in daytime urine samples, there were no differences. Similarly, the urinary calcium and protein excretion in nighttime urine samples were distinctly higher in the group of enuretic children with polyuria, compared to enuretic children without polyuria and the control group (p<0.05; Table IV). Mean TPR values were comparable.

Comparison of 24-hour ABPM parameters of the children included in the study showed only one significant difference which was the systolic blood pressure load. Daytime systolic blood pressure load was significantly higher in enuretic children with polyuria compared to those enuretic children without polyuria

Table II. 24-hour urine findings of enuretic children and the control group.

Variables	Enuretic Children (N=83)	Control Group (N=62)	P value
Daytime urine volume (ml/kg/h)	1.3 ± 0.8	1.1 ± 0.5	>0.05
Nighttime urine volume (ml/kg/h)	1.1 ± 0.7	0.9 ± 0.5	<0.05*
FENa in daytime urine (%)	1.2 ± 1.8	0.9 ± 0.7	>0.05
FENa in nighttime urine (%)	1.0 ± 1.4	0.5 ± 0.3	<0.05*
FEK in daytime urine (%)	6.3 ± 5.4	7.9 ± 1.9	>0.05
FEK in nighttime urine (%)	2.2 ± 2.9	1.5 ± 1.5	<0.05*
Daytime urinary calcium excretion (mg/kg/day)	1.2 ± 1.1	1.2 ± 1.2	>0.05
Nighttime urinary calcium excretion (mg/kg/day)	0.7 ± 0.6	0.5 ± 0.4	>0.05
Daytime urinary protein excretion (mg/m²/h)	4.6 ± 3.5	5.4 ± 4.5	>0.05
Nighttime urinary protein excretion (mg/m²/h)	5.1 ± 4.9	5.3 ± 5.5	>0.05
TPR daytime (%)	95.2 ± 3.8	93.6 ± 11.2	>0.05
TPR nighttime (%)	94.6 ± 3.1	94.9 ± 5.8	>0.05

Data are presented as mean ± standard deviation.
FENa: fractional excretion of sodium, FEK: fractional excretion of potassium, TPR: tubular phosphorus reabsorption.

Table III. 24-hour blood pressure monitoring data of enuretic and control group.

Variables	Enuretic Children (N=83)	Control Group (N=62)	P value
MAP daytime (mmHg)	81.3 ± 5.0	83.1 ± 6.7	>0.05
MAP nighttime (mmHg)	72.2 ± 5.6	73.4 ± 4.7	>0.05
SBP daytime (mmHg)	104.1 ± 6.5	107.2 ± 8.4	<0.05*
SBP nighttime (mmHg)	94.7 ± 7.4	97.1 ± 7.1	>0.05
DBP daytime (mmHg)	62.0 ± 4.8	63.2 ± 6.8	>0.05
DBP nighttime (mmHg)	53.2 ± 5.0	53.9 ± 4.4	>0.05

Data are presented as mean ± standard deviation.
*p < 0.05
DBP: mean diastolic pressure, MAP: mean arterial pressure, SBP: mean systolic pressure.

Table IV. 24-hour urine findings of enuretic children with/without polyuria and control group.

Parameters	Enuretic children with polyuria (N=24)		Enuretic children without polyuria (N=59)		Control Group (N=62)	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
FENa (%)	1.7 ± 3.3	1.4 ± 1.9 *, a	1.0 ± 0.8	0.7 ± 0.4 *, a	0.9 ± 0.7	0.5 ± 0.3 *, a
FEK (%)	7.8 ± 5.2	3.8 ± 2.8 *, a	5.9 ± 5.5	1.6 ± 2.7 *, a	8.0 ± 1.9	1.5 ± 1.5 *, a
Protein excretion (mg/m2/h)	5.5 ± 3.1	7.9 ± 7.9 *, a	4.3 ± 3.6	4.2 ± 2.9 *, a	5.5 ± 4.5	5.4 ± 5.5 *, a
Calcium excretion (mg/m2/h)	1.2 ± 0.7	0.9 ± 0.5 *, a	1.2 ± 1.2	0.6 ± 0.7 *, a	1.2 ± 1.3	0.5 ± 0.4 *, a
TPR (%)	94.6 ± 2.5	94.0 ± 2.4	95.4 ± 4.2	94.8 ± 3.3	93.6 ± 11.3	94.9 ± 5.8

Data are presented as mean ± standard deviation.
FEK= fractional excretion of potassium, FENa: fractional excretion of sodium, TPR: tubular phosphorus reabsorption.
*p < 0.05
a: nighttime FENa, FEK, protein, and Ca excretion were significantly higher in enuretic children with polyuria, compared to enuretic children without polyuria and the control group.

Table V. 24-hour blood pressure monitoring data of enuretic children with/without polyuria and the control group.

Parameters	Enuretic children with polyuria (N=24)		Enuretic children without polyuria (N=59)		Control Group (N=62)	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
SBP (mm Hg)	105.7 ± 6.7	94.8 ± 5.6	103.5 ± 6.7	94.5 ± 7.3	106.8 ± 8.1	96.8 ± 6.9
SBP-SDS	0.0±0.8	-0.1 ± 0.7	-0.2 ± 0.8	-0.1 ± 0.9	0.1 ± 1.0	0.1 ± 0.9
DBP (mm Hg)	63. 3± 4.2	53.3 ± 4.3	61.7 ± 4.8	53.0 ± 4.0	62.8 ± 6.5	53.8 ± 4.4
DBP-SDS	0.1 ± 0.7	-0.0 ± 0.9	-0.1 ± 0.8	-0.1 ± 0.8	0.0 ± 1.1	0.0 ± 0.9
MAP (mm Hg)	82.5 ± 4.9	72.3±4.7	80.9 ± 5.0	71.8 ± 4.7	82.9 ± 6.6	73.4 ± 4.7
MAP-SDS	0.0 ± 0.8	-0.0 ± 0.8	-0.2 ± 0.8	-0.1 ± 0.8	0.1 ± 1.1	0.1 ± 0.8
SBP load (%)	6.8 ± 8.9 *	7.8 ± 16.4	4.6 ± 6.4*	7.9 ± 14.5	8.7 ± 10.1	10.5 ± 15.5
DBP load (%)	5.2 ± 11.8	9.8 ± 9.8	6.5 ± 8.4	10.4 ± 9.4	6.7 ± 9.0	12.7 ± 12.6
SBP dipping (%)	10.2 ± 3.4		9.4 ± 4.1		9.6 ± 4.9	
DBP dipping (%)	15.7 ± 4.9		13.9 ± 6.1		14.1 ± 7.3	

Data are presented as mean ± standard deviation.
DBP: diastolic blood pressure, MAP: mean arterial pressure, SBP: systolic blood pressure, SDS: Standard derivation score
*p <0.05; daytime systolic blood pressure load was significantly higher in enuretic children with polyuria compared to those enuretic children without polyuria

(p<0.05). When all three groups are compared, the highest MAP pressure was found in the control group, but it did not reach to statistical significance (p >0.0.5, Table V).

No significant correlation was determined between the ABPM parameters and urinary excretion of electrolytes day and nighttime. Similarly, serum renin and aldosterone levels were not correlated with ABPM parameters (p>0.05).

Discussion

Monosymptomatic nocturnal enuresis is a multifactorial health issue that affect approximately 10% of children between the ages of 5 -10 years.[7] Children with normal pediatric development, daytime bladder control is usually achieved between the age of 2–3 years and nighttime control is developed around 3–5 years of age. According to the criteria of International Children's Continence Society, children over 5 years of age are expected to have urinary control during sleep.[8] For this reason, our study included 83 enuretic children above 5 years of age with an average age of 9.2 ± 2.6 years.

It has been shown that enuresis is seen equally in both genders until the age of five, then the incidence increases gradually in boys and its incidence is twice higher in boys than girls around the age of 11.[9] In our study, 60.2% of the enuretic children were boys, which was compatible with the literature.[10] The frequent occurrence of enuresis in boys can be attributed to the lower rate of spontaneous recovery and the higher frequency of secondary enuresis in boys.[11,12]

In our study, the electrolyte excretion in daytime and nighttime urine samples of enuretic children and the children in the control group were calculated. No difference was determined on the daytime mean FENa and FEK values but the mean FENa and FEK values calculated in nighttime urine samples of enuretic children was found to be significantly higher than the control group. Review of the literature shows that FENa and FEK excretion were found to be higher in children with MNE compared to controls.[13] Another study including 30 enuretic children showed only increased potassium excretion.[5] Increased potassium excretion in those children suggests that there may be failure of some potassium -regulating mechanisms in distal tubules. Excessive K+ in the distal tubule together with the low ADH in enuretic may cause less tubular fluid reabsorption, and insufficiently reabsorbed K+ remains in the distal tubule concomitantly with water. Kir 4.1 is expressed in the kidney with high specificity only in the distal convoluted tubule (DCT) on the basolateral membrane, and speculated that it is critical for K+ recycling. KCNJ10 channel protein is a member of the Kir 4.1 family.[13] Balat et al.[13] studied relation between urinary electrolytes, especially K+ and KCNJ10 gene promoter polymorphism. They found that SNP3 in promoter of KCNJ10 gene was strongly associated with either distribution of genotype and allele frequency in enuretic, and TT genotype was associated with higher urinary K+ excretion. They also suggested that determination of the relationship between KCNJ10 gene polymorphism and polyuria in enuretic children could be more informative.

When polyuric–non polyuric children and control group were compared in terms of urinary excretion of electrolytes in our study, no difference was determined in daytime urine samples. In children with nocturnal polyuria, however, the mean nighttime FENa, the mean nighttime FEK urinary excretion, protein and calcium excretions were found to be significantly higher. These data, which are compatible with previous studies, suggest that FENa correlates with nocturnal polyuria and nocturnal enuresis, especially in enuretic patients with polyuria.[12]

When enuretic children and the control group were compared in terms of urinary calcium and protein excretion and TPR in daytime and nighttime urine samples, no significant difference was found between these two groups. When these parameters were evaluated

regarding enuretic children with vs. without nocturnal polyuria and the control group, however, the urinary calcium and protein excretion of children with nocturnal polyuria was determined to be higher. Raes et al.[14] determined hypercalciuria in 12% of children with nocturnal enuresis and stated a correlation between urinary calcium excretion, nocturnal urine volume and increased sodium excretion in urine. However, hypercalciuria is a symptom already present in the normal population with a ratio around 3 - 7%. Furthermore, enuresis is a symptom that can be seen in cases with primary hypercalciuria. Depending on these data, it can be stated that this correlation between enuresis and hypercalciuria should not be considered as a primary factor but as a co-morbid factor in the pathogenesis of enuresis.

Increased Na and K excretion accompanied by increased protein and calcium excretion in nighttime urine samples of enuretic children with nocturnal polyuria as shown by our study suggests that renal tubular defects may have a role in the etiopathogenesis in enuretic children with nocturnal polyuria. Yet, it should be also kept in mind that hormonal factors also have a role in the regulation of renal water and solute excretions. The literature contains limited data regarding the role of atrial natriuretic peptide, renin, aldosterone and angiotensin-2 in the etiology of enuresis.[3] In our study, enuretic children and control group were compared in terms of renin and aldosterone levels but no significant difference was found. Kamperis et al.[15] compared ANP, angiotensin-2, aldosterone and renin levels and, they determined no difference between enuretic children and the control group which is similar to the findings of our study. However, in the same study, a significant increase was determined in the prostaglandin E-2 (PGE2) level of patients with nocturnal polyuria and it was suggested that renal prostaglandins were the key molecule in the etiopathogenesis of enuresis. PGE2 prevents ADH's effects on tubular water reabsorption and at the same time potentiates its natriuretic effect. For this reason, even though the natriuresis in children with nocturnal polyuria cannot be directly explained with abnormalities in the circadian rhythm of ANP, renin, aldosterone and angiotensin-2, it is possible that increased PGE2 is the main factor responsible for this occurrence.[16]

When enuretic children and the control group was compared in terms of the findings of ABPM, no significant difference was determined between the two groups in terms of the MAP and the DBP values that were measured both during daytime and nighttime. The only difference determined between the two groups was the lower SBP in the enuretic group. However, it was considered that this reduction in daytime values was not involved in the pathogenesis of enuresis. Additionally, enuretic children with versus without nocturnal polyuria and the control group were also compared. No significant difference was found among all three groups in terms of the SBP, DBP and MAP as measured both daytime and nighttime.

Review of the literature shows that most of the studies on this subject revealed no significant difference between the nocturnal blood pressure values of enuretic children with polyuria versus without polyuria.[17,18] Normally, nocturnal decrease in urine production is accompanied by reduced blood pressure during sleep. On the basis of this information, one can expect to determine some variations in nocturnal blood pressure pattern in enuretic children with nocturnal polyuria. In order to explain why ABPM findings of children with polyuria versus without polyuria were found to be similar in our study and some other studies in the literature, one can speculate that sleep patterns of enuretic children included in the study may be different or disturbed. Another reason for this finding may be the presence of additional pathophysiological mechanisms, other than nocturia, affecting the blood pressure. Contrary to the data in our study, in a study conducted by Anne et al.[17] higher MAP values were found in enuretic children with nocturnal polyuria compared to enuretic children without nocturnal polyuria and to

the control group and it was reported that the enuresis might be caused by polyuria resulting from this increase in blood pressure. In another study evaluating the role of autonomic activity in the pathogenesis, selective nocturnal increase in the mean diastolic and mean arterial pressure was found in children with enuresis, and this increase was thought to be associated with sympathetic nervous system hyperactivation.[2]

Various conclusions in the literature related to nocturnal blood pressure changes in children with enuresis may be related to variability of nocturnal activity of the autonomic nervous system. Dundaroz et al.[19] analyzed the heart rate changes in children with nocturnal enuresis and increase in heart rate supporting sympathetic hyperactivity was determined.[20] Contrary to this, many studies in this field showed existence of parasympathetic neural system hyperactivity and consequent bladder hyperactivity.[20] Conflicting results in the literature, give rise to the thought that the autonomic nervous system can be more active in sympathetic or parasympathetic way in different enuretic patient groups.

According to the theory that anticipates a relationship between nocturnal blood pressure changes and enuresis; in enuretic children, it is expected that the nocturnal increase of blood pressure should increase glomerular filtration and consequently the urinary solute excretion. As a result, urinary volume should increase during the night. However, from the data obtained in our study, no correlations between ABPM findings and urinary electrolyte excretions and volumes were found.

In the literature, the nocturnal blood pressure increase was determined predominantly in enuretic children with polyuria.[17] In general, also in our study, approximately one out of every five enuretic children showed polyuria. However, results of separate evaluations of cases with polyuria provided similar nocturnal blood pressure levels with those without polyuria. These findings support the idea that the nocturnal blood pressure changes are not an invariable finding in enuretic children and that in addition to the blood pressure, different pathogenic mechanisms play a role in the etiology of enuresis.

In the literature, there are various studies on nighttime urinary electrolyte excretion in enuretic children. However, the number of studies on blood pressure changes in enuretic children is limited. Yet, our study included the highest number of patients compared to other studies. Additionally, the study bears a certain significance by evaluating both blood pressure and urinary volume as well as urinary electrolyte excretion. We can conclude that our study reflects the findings of enuretic children on a broader basis and provides more reliable data since it included a large number of patients than any other study in the literature and since it examined various parameters and their correlations. Our study compared the ABPM findings and urinary electrolyte excretions in detail rather than a specific pathogenetic mechanism, which may be considered a limitation. But still, this may provide a broader view to the subject.

In conclusion; it has been shown that nighttime urinary solute excretion is higher in enuretic children. This finding may play a role in the pathogenesis of nocturnal polyuria. Furthermore, it has been found that nocturnal blood pressure changes are not invariably present in all enuretic children. As a result, it has been concluded that pathogenesis of enuresis is multifactorial and different factors may play a role in each individual patient.

Ethical approval

The study was approved by the Ethics Committee of Ministry of Health Ankara Training and Research Hospital (no: 0398/2010).

Author contribution

The authors confirm contribution to the paper as follows: study conception and design: ZSE, PIA; data collection: ZSE, SE; analysis and interpretation of results: ZSE, PIA; draft manuscript preparation: ZSE, PIA, SE, YBD. All authors reviewed the results and approved the final version of the manuscript.

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Conflict of interest

The authors declare that there is no conflict of interest.

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