ORIGINAL ARTICLE

Indonesia Journal of Biomedical Science (*IJBS*) 2021, Volume 15, Number 1: 63-67
P-ISSN.2085-4773, E-ISSN.2302-2906

Published by
Indonesia Journal of Biomedical Science

The voiding pattern of aterm neonates

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Received: 2021-02-19
Accepted: 2021-04-30
Published: 2021-05-15

ABSTRACT

Introduction: The concept of voiding patterns in neonates had not been completely understood. The voiding pattern in neonates was physiologically different from that in older children. The brain's development affects voiding patterns in frequency, bladder volume, and post-void residual bladder volume, as the child keeps growing. This study aims to understand the physiological neonates' voiding system in Indonesian newborns.

Materials and methods: We evaluate ten normal-born and 12 perinatology-hospitalized aterm neonates without anatomical or physiological urologic abnormalities at RSUP Haji Adam Malik from October to November 2019. We used an observational study, assessing the voiding physiology in newborns, including voiding frequency and urine volume. Infants with a history of urinary tract infection or present bacteriuria confirmed by urine culture were excluded. Voiding volume, frequency, bladder capacity, and residual volume were measured.

Results: We collected a total of 22 patients, with 12 patients were perinatology-hospitalized and ten patients were healthy neonates with ten subjects were male, and 12 subjects were female. There was no correlation between voiding frequency and total voiding volume with perinatology-hospitalized, healthy neonates, and sex. ($p>0.05$). Independent T-test was performed with a p-value for volume, frequency, bladder capacity, and residual volume of 0.225, 0.112, 0.031, and 0.663. We got a significant difference in bladder capacity between healthy neonates and perinatology-hospitalized. No significant differences were noted in other variables. Pearson correlation analysis was performed to determine the correlation between total voiding volume and age of gestation, body weight, length, head circumference, abdominal circumference, and chest circumference. The correlation coefficients were 0.772, 0.869, 0.623, 0.698, 0.079, 0.523 in order, with significant p-value in the age of gestation, body weight, length, head circumference, and chest circumference. There were correlations between total voiding volume and age of gestation, body weight, length, head circumference, and chest circumference.

Conclusion: In conclusion, we found there was a significant difference in bladder capacity between healthy neonates and perinatology-hospitalized.

Keywords: healthy neonates, perinatology-hospitalized neonates, voiding pattern.

Cite this Article: Ginting, J.T., Sigumunrong, Y. 2021. The voiding pattern of aterm neonates. *IJBS* 15(1): 63-67. DOI: 10.15562/ijbs.v15i1.300

INTRODUCTION

The concept of voiding patterns in neonates had not been completely understood. The voiding pattern in neonates was physiologically different from that in older children. It was thought before that the brain did not influence voiding in neonates. Nevertheless, during the last decade, studies had found that the brain is involved in the regulation of bladder function during the neonatal period, although the function is immature and the signal only disturbs the neonate.

The brain's development affects voiding patterns in frequency, bladder volume, and post-void residual bladder volume, as the child keeps growing. The frequency of voiding in the newborn during the first year of life was approximately once per hour or about 20 voids per day with a volume of 20 to 25 ml for each void. The volume may vary in all voiding parameters. Within the next two years, there was a decrease in voiding frequency to about 11 voids per day, accompanied by an increase in voided volume as much as fourfold. The frequency of voiding decreases to 4-6 voids per day by the age of 12.[1] The median voided volume in infants was 23 ml. The residual volume higher than 10 ml was observed in 70% of infants. Double voiding was observed in almost half of the newborns.[2] Voiding patterns in infants and non-toilet-trained-children can be measured by 4-hour voiding observation. The frequency of urination was once per hour with a great variation. There was an increase in older patients' bladder capacity with the formula: 38 + 2.5 x age (months). The mean residual urine observed was 4.6 ± 3.0 ml. All infants had residual volume less than five ml.[3]

The neonatal period was critical in bladder development, encompassing the transition from fetal bladder contractions to voluntary infant urination. Lower urinary tract physiology was dynamic as mature bladder function develops in a growing child. Recent studies have shown that the arousal reaction is controlled by the cortical center in both healthy preterm and normal infants.

However, the infantile voiding mechanism remains obscure. Neonates had small, frequent voids with different volumes. The regulation of neonatal bladder involves neuronal pathways to the cerebral cortex in the neonatal period. This theory was different from the previous theory which stated that voiding occurs automatically in response to a constant volume in the bladder.[4] Nowadays, ultrasound had become available as a noninvasive means to evaluate bladder urine volume and residual volume.

Currently, there were not many studies focusing on the physiological voiding system in neonates. Previous studies also used foreign newborns as subjects. Therefore, this study aims to understand the physiological neonates voiding system in Indonesian newborns.

MATERIALS AND METHODS

This was an observational study assessing the voiding physiology in newborns, including voiding frequency and urine volume. Samples were taken from ten normal-born and 12 perinatology-hospitalized term neonates without anatomical or physiological urologic abnormalities at RSUP Haji Adam Malik from October to November 2019. Exclusion criteria were infants with a history of urinary tract infection or present bacteriuria confirmed by urine culture. Informed consent for joining the study was obtained from the parents of the subjects.

At first, dry-weighed diapers were applied. The children's diapers were pre-weighed and were examined every 5 minutes. A gossip strip was observed to determine the voiding. Wet gossip strip demonstrated voiding. Voiding volume was assessed by measuring the weight of the diaper. The diaper was opened 30 seconds following the wet gossip strip's onset to make sure that the voiding was not interrupted.

The frequency of voiding was assessed by measuring the total of voiding during 4-hour observation, without interrupting voiding. Interrupted voiding, defined as two or three voidings within less than a 10-minute interval and the lowest amount of residual urine after the final voiding. The interrupted voiding was regarded as one voiding. During a 4-hour observation between 9 AM until 1 PM, the frequency of voiding and voiding volume was obtained.[2,3] Bladder volume before voiding is calculated by the sum of voiding volume and post-void residual bladder volume.

In this study, we did not use ultrasound to check bladder volume and post-voiding residual volume due to functional limitations and availability of the tools. Data of voiding frequency and voiding volume was presented as mean and standard deviation or median and minimum and maximum value.[3]

RESULT

We collected a total of 22 patients, with 12 patients were perinatology-hospitalized and ten patients were healthy neonates with ten subjects were male, and 12 subjects were female (Table 1). From all subjects, we got the mean of gestational age is 37.18 weeks. The mean for body weight was 2,719 grams. The mean for length was 47.40 cm. The mean for head circumference was 34.11 cm. The mean for abdominal circumference was 31.13. The mean for chest circumference was 32.68 (Table 2). We got the mean for voiding frequency is 3.18 times and the total voiding volume was 88.63 ml (Table 3). We used the Kolmogorov-Smirnov test to determine the data distribution and all variables were normally distributed.

We used the independent T-test to determine the correlation between voiding frequency and total voiding volume between perinatology-hospitalized and normal healthy neonates. From the analysis, we got p-value of 0.225 with 95% CI (-35.9 – 9.75) and p-value of 0.679 with 95% CI (-1.29 – 0.85). We also used the independent T-test to determine the correlation between voiding frequency and total voiding volume with sex. We got p 0.523 with 95% CI (-1.41 – 0.735) and 0.896 with 95% CI (-13.05 – 32.71). We could conclude, there was no correlation between voiding frequency and total voiding volume with perinatology-hospitalized, normal healthy neonates, and sex (Table 4).

From this data, we analyzed four characteristics for voiding: the total volume, frequency, bladder capacity, and residual volume. From the data, we knew that the mean of each variable was 88.63, 3.36, 39.15, and 4.25. From the data, we analyzed the mean of each variable to our group (healthy neonates and perinatology-hospitalized) using the independent T-test (Table 5).

Table 1. Characteristics of variable (categorical data)

	Number	Percent (%)
Group		
Perinatology	12	54.5
Healthy	10	45.5
Sex		
Male	10	45.5
Female	12	54.5

Table 2. Characteristics of variable (numerical data)

Variable	Mean (Min-Max)	SD
Age of Gestation	37.18 (30 – 42)	3.23
Body Weight	2,719 (1400 – 3950)	675.50
Length	47.40 (34 – 55)	4.41
Head Circumference	34.11 (31 – 43,5)	2.73
Abdominal Circumference	31.13 (29 – 38)	2.47
Chest Circumference	32.68 (31 – 36)	1.32
Voiding Frequency	3.18 (1 – 6)	1.18
Voiding Volume	88.63 (50 – 140)	25.50

Table 3. Characteristic for healthy neonates and perinatology-hospitalized

Variable	Healthy Neonates Mean (Min-Max)	Perinatology-Hospitalized Mean (Min-Max)
Volume	82.5 (50 – 140)	96 (70 – 140)
Frequency	3.08 (2 – 5)	3.7 (3 – 5)
Bladder Capacity	38.01 (33.74 – 44.19)	40.51 (38.66 – 43.48)
Residual Volume	4.32 (3.05 – 5.38)	4,17 (3.38 – 5.32)

We compared the mean of each voiding parameter to sex. From the data, we got the mean of volume, frequency, bladder capacity in healthy neonates male and female respectively were 100, 3.83, 39.78, 4.57, and 65, 2.3, 36.24, 4.07. In perinatology-hospitalized, we got the mean of volume, frequency, bladder capacity and residual in male and female, respectively were 85, 3.5, 39.91, 4.06, and 103.3, 3.83, 40.91, 4.25. We used the independent T-test to measure the correlation. However, we did not find any correlation between them (Table 6).

From our analysis, we got the p-value for volume, frequency, bladder capacity, and residual volume were 0.225, 0.112, 0.031, and 0.663 in order. We got a significant difference in bladder capacity between healthy neonates and perinatology-hospitalized. No significant difference was noted in other variables (Table 7).

We used the Pearson correlation test to determine the correlation between voiding frequency and age of gestation, body weight, length, head circumference, abdominal circumference, and chest circumference. The correlation coefficients were 0.078, 0.181, 0.113, 0.148, 0.025, and 0.222. (p>0.05) (Table 8).

We used the Pearson correlation test to determine the correlation between total voiding volume and age of gestation, body weight, length, head circumference, abdominal circumference, and chest circumference. The correlation coefficients were 0.772, 0.869, 0.623, 0.698, 0.079, 0.523 respectively with a significant p-value ($p<0.05$) in the age of gestation, body weight, length, head circumference, and chest circumference. We found correlations between total voiding volume and the age of gestation, body weight, length, head circumference, and chest circumference (Table 8).

Table 4. **Correlation with independent t-test**

Variable	Voiding Frequency p, (95% CI)	Voiding Volume p, (95% CI)
Group	0.679, (-1.29 – 0.85)	0.225 (-35.9 – 9.75)
Sex	0.523, (-1.41 – 0.735)	0.896 (-13.05 – 32.71)

Table 5. **Voiding characteristics**

Variable	Mean (Min-Max)	Std. Deviation
Volume	88.63 (50 – 140)	25.50
Frequency	3.36 (2 – 5)	0.90
Bladder capacity	39.15 (33.74 – 44.19)	2.76
Residual	4.25 (3.05 – 5.38)	0.705

Table 6. **Voiding Parameter (Mean and standard deviation) based on sex**

Variable	Healthy Neonates		Perinatology-Hospitalized	
	Male	Female	Male	Female
Volume	100 ±24.49	65 ± 16.43	85 ± 17.32	103.3 ± 24.22
Frequency	3.83 ± 0.75	2.3 ± 0.51	3.5 ± 0.57	3.83 ± 0.75
Bladder capacity	39.78 ± 2.87	36.24 ± 2.11	39.91 ± 1.05	40.91 ± 1.99
Residual	4.57 ± 0.66	4.07 ± 0.78	4.06 ± 0.43	4.25 ± 0.85

Table 7. **Compare means between healthy neonates and perinatology-hospitalized with voiding characteristics with Independent T-test**

Variable	p, 95% CI Group
Volume	0.225 (-35.97 – 8.97)
Frequency	0.112 (-1.39 – 0.17)
Bladder capacity	0.031* (-4.74 – 0.24)
Residual	0.663 (0.49 – 0.79)

DISCUSSION

Urine was produced from the kidneys through the ureters (25–30 cm long in adults), which enter the bladder via a region near the base of the bladder called the trigone. Two constrictions assist the flow from the pelvis into the ureter and from the ureter to the bladder at opposite ends: the ureteropelvic junction (UPJ) and the ureterovesical junction (UVJ) respectively. These unique fibromuscular structures, which are not strictly classic sphincters, provide antireflux protection in order to ensure that urine transport occurs in only one direction. The ureters consist of stratified layers composed of the epithelium (the urothelium), lamina propria, and smooth muscle.[1]

The bladder has two complementary functions, to retain urine as it collects from

Table 8. **Correlation with the Pearson test**

Variable	Voiding Frequency	p	Voiding Volume	p	Bladder capacity	p	Residual volume	p
Age of Gestation	0.078	0.729	0.772	0.000*	0.860	0.000*	0.302	0.171
Body Weight	0.181	0.429	0.869	0.000*	1.000	0.000*	0.255	0.251
Length	0.113	0.617	0.623	0.002*	0.754	0.000*	0.246	0.270
Head Circumference	0.148	0.511	0.698	0.000*	0.694	0.000*	0.230	0.302
Abdominal Circumference	0.025	0.911	0.079	0.728	0.014	0.915	0.291	0.189
Chest Circumference	0.222	0.321	0.523	0.013*	0.459	0.032*	0.552	0.013*

*significant, *p<0,05*

the ureters and to expel it periodically during the act of voiding. Incontinence may result either from a failure of the normal mechanism of retention or from a lack of voluntary control of the normal process of emptying. When voiding takes place three things occur, the intravesical pressure is raised, the outflow resistance is reduced, and finally, the urethra is emptied.[2]

The intravesical pressure is raised by a coordinated contraction of the detrusor muscle, resulting from a spinal reflex sited in the sacral cord. The afferent stimulus for this reflex is from pressure receptors in the bladder wall and the reflex is perpetuated until the bladder is empty from the stimulus of urine under pressure in the urethra.[2]

Voiding during infancy is assumed to be an automatic event initiated by bladder distention at a constant volume, and mediated via the micturition reflex to the brainstem and back to the bladder without activation of cortical centers, as in humans with mature bladder function.[3]

In the voiding process in infants, there are some differences compared to adults. The difference includes diuresis, bladder capacity, arousal, voided volume, post-void residual urine, and voiding frequency. In the filling phase, diuresis and bladder capacity play a significant role. Diuresis in preterm infants is larger than in "term" born children. The hourly urine production assessed by flowmetry (ml/kg/hour) of male infants (gestational age 31.3 weeks) is more capacious than the one in "term" newborns. In terms of bladder capacity, A higher diuresis leads to a higher maximal voided volume increases parallel with bladder capacity. Generally, it can be stated that the bladder capacity increases with age.[3-5] Most voids in infants occur when being awake or the infants awake immediately before voiding. Overall, this suggests that during voiding while sleeping, cortical arousal can be present. Post-void residual (PVR) urine in preterm infants (mean gestational age 29 weeks) was 11.9 % of EBC, whereas in "term" children, this percentage is smaller (8.8 %). However, a range in PVR of 0–22 % was encountered ("a term", 1.8–12.3 months).[3]

During the first few days of life, voiding frequency (VF) is very low. No significant change was detected in VF between exclusively or partially breastfed neonates. In preterm infants (0–28 days, mean gestational age 32.7 weeks), a peak is seen at days 1–4 and from day four until day seven. Premature children have a higher VF than "term" infants. Whereas in "term" infants, VF only increased significantly at days 4–7.[3]

Due to the large difference in bladder capacity, it seems of little value to use standard formulas to estimate the normal capacity of infants. The suggested the formula: bladder capacity (in milliliters) 4.38 + 2.5 × age in months. This formula was derived from observations in infants older than 8 weeks. When applied to the present group of infants, it gave a bladder capacity of 39 mL. This volume lies between the observed median value for maximal voided volume (34 mL) and bladder capacity (48 mL).[6,7]

We determine our sample's bladder capacity with formula stated by Jae et al. In their study in the Korean population. A formula that approximates bladder capacity with respect to age is the following: bladder capacity (ml) = [1.6 x age (months)] + 45. A formula that approximates bladder capacity with respect to weight is the following: bladder capacity (ml) = [4.1 x weight (kg)] + 28.[5,7] In our data, we found that there was no correlation between healthy neonates, perinatology-hospitalized and sex and voiding frequency and voiding volume. Sillen et al.[8] perform the same experiment comparing sex (male and female) with voiding frequency, intermittent voiding and voiding volume. They conclude that there was no correlation between them.[5,7]

We found a correlation between voiding volume and age of gestation, body weight, body length, head circumference, and chest circumference. Voided volume increases significantly according to age especially after the first six months of life. The voided volume of preterm infants is generally smaller than that of "term"-born infants. It ranged in preterm infants from 6.7–14.1 ml. whereas in "term" infants, the voided volume can be as large as 77 ml.[1,3,9,10]

From the analysis, we did not find any different mean between healthy neonates and perinatology-hospitalized in terms of total volume, frequency and residual. However, we get significant differences in bladder capacity. In our finding, related to residual urine, premature and newborn baby has a similar residual volume In terms of frequency, our data was contradictive with a review paper stated by Kelly et al. that there was a difference between preterm and healthy neonates, while, in our data, we could not find any difference.[3,5,11] We got a significant difference between healthy neonates and perinatology-hospitalized baby. A review paper stated by Kelly et al. stated that there was a significant change in bladder capacity in age groups.[3,10,12]

CONCLUSION

In conclusion, we found omit a significant difference in bladder capacity between healthy neonates and perinatology-hospitalized. We also find a correlation between voiding volume and age of gestation, body weight, body length, head circumference, and chest circumference. This research will open opportunities to other researchers related to urology topics in pediatrics. We hope, in the next research, urodynamic and USG will be performed in order to a better evaluation regarding the voiding parameter to achieve a better result.

ACKNOWLEDGMENT

The authors would like to thank everyone who supports them during the writing of this paper.

FUNDING

This study doesn't receive any specific grant from government or any private sector.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTION

All authors had contributed for writing the original draft and agreed for the final version of the manuscript for publication.

ETHICAL CONSIDERATION

This study has been approved by Ethical Committee Faculty of Medicine, Universitas Sumatera Utara/Haji Adam Malik Hospital, Medan, Indonesia.

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