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Effects of umbilical venous catheters on arrhythmia and heart rate variability in premature newborns

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Summary

Aim: Cardiac rhythm abnormalities associated with umbilical venous catheters in newborns are limited to anecdotal case reports. The present study intended to evaluate association between umbilical venous catheter, arrhythmic potential, and changes in heart rate variability.

Material and Method: The study consisted of two groups; 26 preterm newborns with a umbilical venous catheter (group 1), and 26 control group without (group 2). The following parameters were recorded prospectively: gender, gestation at birth, birth weight, and clinical assessment scores (SNAP-II and SNAPPE-II). Holter recordings were fitted in all newborns. The heart rate variability study was performed by utilizing time-domain and frequency-domain analyses.

Results: The study population consisted of group 1 (30.63±2.67 weeks of gestation) and group 2 (31.60±2.45 weeks of gestation). There was no statistical difference between the two groups for gestational age, birth weight, SNAP-II and SNAPPE- II scores. When compared for arrhythmia there was no statistical difference in any parameters between the two study groups. Premature atrial contraction was noted in 11 babies (42.3%) in group 1 and in 7 babies (26.9%) in group 2. Premature ventricular contraction was noted in 3 babies (11.5%) in group 1 and in one baby in group 2. Sinus tachycardia detected in 3 patients in only the group 1. None of the heart rate variability parameters were found to be statistically different between the two groups.

Conclusions: Our study reassuringly demonstrated that umbilical venous catheter does not have any significant effect on arrhythmia or heart rate variability in preterm newborns. *(Turk Arch Ped 2013; 48: 131-137)*

Key words: Arrhythmia, heart rate variability, newborn

Introduction

Placement of umbilical venous catheter in preterm newborns in neonatal intensive care units is a commonly performed procedure. Umbilical venous catheter (UVC) is a permanent and safe vascular access for frequent blood sampling, drug administrations, intravenous fluid administration and total parenteral feeding (1,2,3,4,5). However, this procedure may lead to extra-cardiac complications including septicemia, air embolism, thrombosis, liver damage, portal hypertension and fistula. Arrhythmias which develop with pericardial effusion, tamponade, atrium and ventricle damage are cardiac complications related with UVC (2,6,7,8,9,10,11,12,13). Although the frequency of these complications is low, their outcomes may be serious. In newborns, rhythm disorders related with UVC are limited with case reports (14,15). In this study, it was planned to determine the effect of UVC on arrhythmia and heart rate variability (HRV). There is no other study which examines the relation between UVC and heart rate variability in the literature.

Material and Method

This study was performed in preterm newborns who were hospitalized in the neonatal intensive care unit. The study included 26 preterm newborns with UVC (Group 1) and 26 preterm newborns without UVC (Group 2).

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Although the patients who were included into the groups were selected randomly, patients whose general states were poor, who had pathologies which would have a negative effect on heart rate and cardiac rhythm, who had morbidities which would require frequent blood tests and measurement of blood gases and who had high SNAPII and SNAPPEII scores were not included in this study. In addition, approval (Project number: 2006-94, approval number: 13/5) was obtained from the ethics committee of our university.

The gender, gestational week, birth weight, diagnosis at admission, treatment administered, complete blood count, serum electrolytes and hepatic and renal function tests in the patients included in both groups were recorded prospectively (Table 1 and 2). Chest graphy and ultrosonographic examinations were performed to determine the location of the umbilical venous catheter. The distance of placement of the umbilical catheter in the umbilical vein was calculated according to the predefined formule in which the body weight was used (16).

The clinical states of the infants could be assessed more objectively using the scoring systems used for prediction of mortality risks of newborns. For this objective "Score for Neonatal Acute Physiology-II" (SNAP-II) and "Score for Neonatal Acute Physiology Perinatal Extension-II" (SNAPPE-II) scoring systems were used. In these scoring systems, the mean blood pressure, the lowest body temperature, sPO_2/ FiO_2 ratio, serum pH value, presence of convulsion, amount of diuresis, birth weight, APGAR value at the 5th minute and presence of low birth weight according to the gestational age are assessed.

24-hour Holter recording was performed in the second day of life in the patients in both groups. After it was observed that serum electrolyte and calcium levels were within the normal limits, 24-hour ECG Holter recordings were started. During the recording, it was ensured that no theophylline or caffeine was received. The lowest, the highest and mean heart rates were determined from the Holter recordings. Arrhythmias were classified as premature atrial beat (PAB), premature ventricular beat (PVB), wandering atrial rhythm, sinus tachycardia, supraventricular tachycardia (SVT), ventricular tachycardia (VT), sinus pause and bradycardia. A hear rate below 80/minute was considered as bradycardia and a heart rate above 220/minute was considered as SVT. Any pause longer than 2 seconds was considered abnormal.

24-hour ECG Holter recordings were evaluated by a pediatric cardiologist using "Pathfinder Holter Analysis System (Delmar Reynolds Medical Ltd., Hertford, UK)".

The heart rate variability was evaluated with time-domain and frequency-domain methods in a 24-hour period. With the time-domain method the following variables were determined: mean R-R intervals (NN), the standard deviation (SDNN) of the time between the successive normal QRS complexes (R-R interval), the Standard deviation (SDANN) of the mean RR intervals on 5-minute recordings during a period of 24 hours, the arithmetic mean value of the R-R intervals on 5-minute recordings during a period of 24 hours (SDNNi), the arithmetic mean value of the square root of the difference between successive R-R intervals (RMSSD) and the ratio of the sum of the intervals with a difference longer than 50 milliseconds between successive R-R intervals to the total R-R number (pNN50). In addition, the "triangular index" which was obtained by transforming the data obtained from the R-R intervals to a geometric figure was assessed. The triangular index is obtained by dividing the intensity of distribution of the R-R intervals to the highest value for intensity of distribution. All measurements were done according to the recommendations of the "European Society of Cardiology" and the "North American Society of Pacing and Electrophysiology" (18).

With the frequency-domain method the low frequency (LF) (0.04-0.15 Hz) and high frequency (HF) (0.15-0.40 Hz) variables obtained from 24-hour recordings were evaluated. These variables were quantified using spectral power curves and expressed as Ln (ms^2/Hz). The LF/HF ratio was found.

Table 1. Diagnoses of the infants at admission in both groups

Diagnosis	Group 1	Group2	Total %
Preterm infant	3	1	7.0
Preterm infant – respiratory distress	4	6	19.2
Preterm infant – respiratory distress syndrome	8	8	30.7
Preterm infant – respiratory distress syndrome-sepsis	6	7	25.0
Preterm infant – neonatal pneumonia	1	-	1.9
Preterm infant – respiratory distress - SGA	4	4	15.3
Total	26	26	100

SGA: Small for gestational age

Echocardiographic examination was performed using 5 or 7 MHz probes (Toshiba Xario; Hewlett Packard, Palo Alto, CA).

The data of the patients were recorded in the SPSS 13.0 (Statistical Package for Social Sciences Statistical Software) program. In the statistical analysis, chi-square test was used for qualitative tests, Mann-Witney U test was used for quantitative tests. The mean± SD values were obtained for all values. A p value of < 0.05 was considered significant.

Results

The gestational age at birth was below 37 weeks in the infants who were included in the study. The mean gestational age of 26 preterm infants in group 1 was 30.63±2.67 weeks and the mean gestational age of 26 preterm infants in group 2 was 31.60±2.45 weeks. No statistically significant difference was found between the two groups in terms of gestational age at birth, birth weight, hemoglobin, mean calcium, potassium, sodium levels and SNAP-II and SNAPPE-II scores (Table 2). Hepatic and renal function tests were found to be normal in all patients.

It was found that the catheter was in the appropriate position in all patients in whom umbilical venous catheter was placed and no change in the location of the catheter was found after Holter was fixed in any patient. On echocardiographic examination, findings including ASD, VSD, patent ductus arteriosus and peripheral pulmonary artery stenosis were found in 8 patients (15.3%). It was accepted that the above-mentioned abnormalities had no effect on cardiac rhythm (Table 3).

No statistically significant difference was found between the groups in terms of arrhythmia variables on 24-hour ECD Holter recordings (Table 4). Premature atrial beat was observed in 11 infants (42.3%) in group 1, while it was found in 7 infants (26.9%) in group 2. Premature ventricular beat was found in three infants (11.5%) in group 1 and in one infant (1.9%) in group 2. All these premature beats were observed as isolated single beats except for dual PVB found in one infant in group 2. Sinus pause longer than 2 s (2.59 s) was found in one infant in group 1. Short-term sinusal tachycardia episodes which resolved spontaneously were observed in three patients in group 1. Wandering atrial rhythm was observed in 2 infants in group 1 and in one infant in group 2. Intermittent atrioventricular block was observed only in one paitent who had UVC. Although the number of infants who were found to have any type of arrhythmia on Holter recordings was 17 (65.4%) in group 1 and 11 (42.3%) in group 2, this difference was not statistically significant (p=0.095) (Figure 1). No life-threatening arrhythmia was found in any patient on Holter recordings.

When the effect of UVC on heart rate variability was evaluated, no statistically significant difference was found in terms of time-domain and frequency-domain variables between the groups with and without UVC (Table 5). There was no relation between heart rate variability and gestational week, SNAP-II and SNAPPE-II.

Discussion

Arrhythmias related with central venous catheters are well known. Similar problems which develop after placement of umbilical venous catheter are limited only with a few cases (15,19). Arrhythmia occuring after placement of umbilical venous catheter is generally related with erroneous placement of the catheter or mechanical

Tablo 2. Comparison of risk scores and laboratory variables between the infants with UVC and the control group

Diagnosis	Group 1 (n=26)	Group 2 (n=26)	p
Gestational week	30.63±2.67	31.60±2.45	0.169
Birth weight (g)	1357±455	1385±337	0.367
SNAP-II	1.27±4.35	0.50±2.5	0.313
SNAPPE-II	7.81±10.84	4.0±9.98	0.067
WBC (/mm^3)	12.688±8.121	15.857±16.063	0.366
Hemoglobin (gr/dL)	15.36±2.46	15.03±2.63	0.641
Platelets (/mm^3)	198.077±82.531	238.663±146.171	0.216
Glucose (mg/dL)	88.26±35.32	92.11±31.8	0.675
Na (mEq/L)	137.4±4.6	138.3±3.4	0.408
K (mEq/L)	4.69±0.63	4.77±0.69	0.655
Ca (mg/dl)	8.56±0.71	8.82±0.8	0.215
AST (IU/L)	60.78±31.8	45.5±23.7	0.05
ALT (IU/L)	18.4±17.3	15±10.3	0.378

Table 3. Echocardiography findings in infants with and without UVC		
Congenital heart disease	**n**	**(%)**
Ventricular septal defect	1	1.9
Atrial septal defect	3	5.8
Ventricular septal defect - Atrial septal defect	1	1.9
Peripheral pulmonary stenosis	1	1.9
Atrial septal defect - Peripheral pulmonary stenosis	1	1.9
Atrial septal defect –Patent ductus arteriosus	1	1.9
Total	8	15.3

Table 4. 24-hour ECG Holter results in the infants with UVC and the control group			
	Group 1 (n=26)	**Group 2 (n=26)**	**p**
Premature atrial beat	11 (42.3%)	7 (26.9%)	0.244
Premature ventricular beat	3 (11.5%)	1 (1.9%)	0.610
Sinusal tachycardia	3 (11.5%)	Yok	0.235
Supraventricular tachycardia	Yok	Yok	-
Ventricular tachycardia	Yok	Yok	-
Bradycardia	7 (26.9%)	4 (15.4%)	0.308
Wandering atrial rhythm	2 (3.8%)	1 (1.9%)	0.435
Intermittent AV block	1	Yok	-
Any arrhythmia	17 (65.4%)	11 (42.3%)	0.095

irritation of the myocardium (20,21). Such complications occur substantially rarely in the childhood. Daniels et al. (7) reported SVT episode related with central venous catheter in the infants. Luesink et al. (22) reported atrial tachycardia episode in a child with a diagnosis of lymphoma. In both studies, it was reported that the reason for tachycardia was mechanical irritation of the myocardium due to the venous catheter and this rhythm disorder was improved when the catheter was removed (7, 22). In another study, complete heart block was reported to have developed after placement of femoral catheter in a premature infant (14).

In the literature, there is no other study focusing specifically on the relation between UVC and arrhythmia. Only two patients who developed atrial flutter after placement of umbilical venous catheter were reported (15, 19). In both patients, the possible reason was accepted to be erroneous placement of the catheter and mechanical irritation. In our study, arrhythmia was not observed in any infant during placement of UVC. After catheterization it was observed radiographically and ultrasonographically that the catheter tip was at the desired level and UVC did not change location spontaneoulsy during the follow up period.

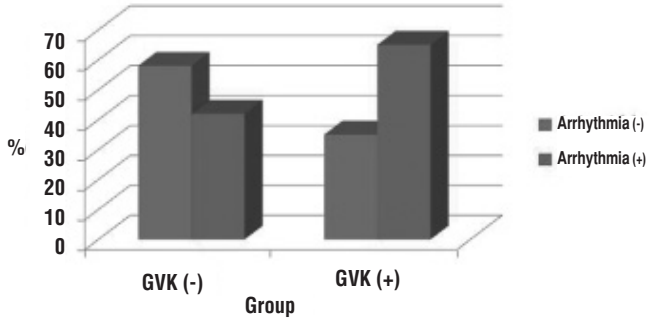

Figure 1. Comparison of the rate of arrhythmia between the infants with and without UVC.

Although fluid and drug administration by way of UVC is considered to be a safe procedure, the effects of these procedures on arrhtyhmia and hear rate have not been studies yet. In an experimental study performed in newborn piglets, ECG monitoring was done after central venous catheter was placed and changes in R-R intervals were examined. As the catheter tip approached the sinoatrial node, it was observed that the R-R interval prolonged

Table 5. Comparison of heart rate variable values between the groups

	Group 1 (n=26)	Group 2 (n=26)	p
The lowest heart rate (beat/minute)	92±35.6	95.8±39.2	0.710
The highest heart rate (beat/minute)	193±19.6	183.8±11.9	0.440
Mean heart rate (beat/minute)	151.4±15.7	149.1±12.3	0.553
NN (ms)	394.2±38.6	401.3±33.5	0.476
SDNN (ms)	32.8±13.2	31±10	0.566
SDNNi (ms)	17.7±10.5	17.2±7.5	0.836
SDANN (ms)	36.1±30.6	28±14.4	0.221
RMSSD (ms)	9.5±3.3	8.9±3.3	0.518
PNN50 (%)	0.4±0.6	0.5±0.6	0.550
TI (%)	3.8±1.5	4±1.5	0.660
LF (Ln[ms^2])	7.5±2.5	7.9±2.1	0.523
HF (Ln[ms^2])	6±2.1	5.9±2.1	0.839
LF/HF oranı	1.2±0.2	1.5±0.7	0.143

NN, mean R-R intervals: SDNN, the standard deviation of the time between the successive normal QRS complexes (R-R interval): SDANN, the standard deviation of the mean RR intervals on 5-minute recordings during a period of 24 hours: SDNNi, the arithmetic mean value of the R-R intervals on 5-minute recordings during a period of 24 hours: RMSSD, the arithmetic mean value of the square root of the difference between successive R-R intervals: pNN50, the ratio of the sum of the intervals with a difference longer than 50 milliseconds between successive R-R intervals to the total R-R number: TI, triangular index, LF low frequency (0.04-0.15 Hz), HF high frequency (0.15-0.40 Hz). LF and HF variables were quantified using spectral power curves and expressed as Ln (ms^2/Hz).

and the heart rate slowed down. In the same study, fluid administrations by way of catheter were also examined and it was observed that the R-R interval prolonged and the heart rate slowed down when the temperature of the fluid administered by way of the catheter was reduced and the R-R interval prolonged when the volume of the fluid given into the right atrium was increased (23). In addition, Kurowski et al. (24) reported that SVT developed in a newborn infant during rapid administration of cefotaxim by way of central venous catheter (24). In light of these two studies it should be considered that the administration speeds, volumes and temperatures of fluids and drugs given by way of central venous catheters may be risk factors in terms of development of arrhythmia and hypothermic fluids or drugs, rapid administration and administration of high volumes should be avoided. In our study, drug and fluid administrations were performed during 24-hour Holter recordings and no increase in the rate of arrhythymia or bradicardia was observed. When compared with the infants who had no UVC, no statistically significant difference was found in terms of Holter variables. However, lack of evaluation of the volumes and temperatures of the fluids and drugs administered was accepted to be a limitation of this study.

In a randomized study performed in the neonatal intensive care unit, UVC was placed in 27 of 457 infants and it was reported that there was no relation between UVC and occurence of any arrhythmia (25). Our study is different from this study in that it was focused on the effect of UVC on arrhythmia and heart rate variability.

Heart rate variability which is evaluated as a determinant of autonomous nervous system has gained significance as a research method in adults and children and limited number of studies have been performed in newborns related with this matter (26,27). Heart rate variability which reflects the interaction between the sympathetic and parasympathetic nervous system shows fluctuations according to the development of the autonomic control in newborns (28,29). The fluctuation in this period are not always related with cardiac pathology and may indicate other extra-cardiac pathologies. Some studies about heart rate variability were conducted with infants with a gestational age above 30 weeks who were relatively more healthier and it was shown that presence of adequate vagal tonus after birth and appropriate heart rate variability variables indicated better long-term outcomes in terms of cognitive functions and social and motor skills (30-33). However, the effect of UVC on HRV has not been investigated in premature infants. In our study, no statistically significant difference was found between the groups in terms of time-domain and frequency-domain variables included in HRV variables. Mehta et al. (27) reported the normal values for HRV in healthy term newborns and it was found that all time-domain variables of HRV were found to be low (27). In our study, HRV variables were found to be lower compared to

the above-mentioned study. Although Khattak et al. (26) reported that LF among the frequency-domain variables increased in proportion with the gestational age, Mehta et al. (27) did not found such a difference in their study. Makarov et al. (34) showed that some time-domain indicators of HRV variables increased from the first day with age (34). The different results obtained in these studies performed in the neonatal period were thought to be related with use of different methods. In our study, no correlation was found between the gestational week and HRV indicators.

The mean SNAP-II and SNAPPE-II scores were similar in both groups. These scores were zero in most of the infants. While the highest values of these scores are 115 and 162, the highest scores in the infants included in our study were found to be 21 and 41. This shows that the infants included in our study were clinically stable or near stable infants. Therefore, it was thought that similar clinical states of the infants in both groups had similar effects on HRV. In addition, all infants included in the study were evaluated in terms of possible organ involvement clinically and ultrasonographically and convulsion, intracranial bleeding or clinical finding of hypoxia was not found in any infant. Thus, it was thought that there was no major CNS affection which might have an effect on HRV. Respiratory arrhythmia which might accompany respiratory diseases and ventilator variables may also affect HRV. However, these data were not evaluated in our study, either. Conclusively, it was thought that UVC and drug and fluid administrations performed by way of UVC had no effect on HRV, since HRV variables shoed similarity in our patient groups.

Conclusively, our study suggests that a proper placement of UVC and fluid and drug administrations performed by this way has no negative effect on development of arrhythmia or HRV in preterm infants, though it included a low number of patients.

Conflict of interest: None declared.

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