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Perception of Pain in the Catheter Angiography Laboratory Among Children with Congenital Heart Disease

Konjenital Kalp Hastalığı Olan Çocukların Kateter Anjiyografi Laboratuvarındaki Ağrı Algısı

ORIGINAL ARTICLE
KLİNİK ÇALIŞMA

ABSTRACT

Objective: This study aimed to evaluate the level of pain caused by routine procedures during cardiac catheterization and explore ways to enhance patient comfort during the procedure based on the findings.

Method: The study involved 24 pediatric patients with congenital heart disease who underwent cardiac catheterization at our center. Pain perception was assessed using skin conductance activity, a non-invasive and sensitive method, at four time points: before the procedure with maternal presence (T0), during local anesthesia following general anesthesia (T1), during femoral vascular intervention (T2), and after the procedure with maternal presence (T3).

Results: Significant differences in pain levels were observed at T0, T1, and T2. While no significant correlation was found between midazolam dosage and pain perception, a statistically significant association was identified between ketamine dosage and pain levels at T3, when the mother was present after the cardiac catheterization.

Conclusion: Effective sedation planning requires a clear understanding of the degree of pain children experience during procedures. This study showed that, despite the use of local anesthetic and procedural sedation, discomfort may still occur. These findings highlight the need for improved pain management strategies to enhance patient comfort during cardiac catheterization.

Keywords: Cardiac catheterization, pain perception, skin conductance activity measurement

ÖZET

Amaç: Bu çalışmada, kardiyak kateterizasyon sırasında yapılan rutin işlemlerin neden olduğu ağrı seviyesini belirlemeyi ve elde edilen bilgiler doğrultusunda işlem sırasında hasta konforunun iyileştirilmesi olasılığını araştırmayı amaçladık.

Yöntem: Çalışmaya merkezimizde konjenital kalp hastalığı nedeniyle takip edilen ve kardiyak kateterizasyon uygulanan 24 hasta dahil edildi. Ağrı algısı, invaziv olmayan ve hassas bir yöntem olan deri iletkenlik aktivitesi kullanılarak anne yanında işlem öncesi (T0), genel anestezi sonrası lokal anestezi sırasında (T1), femoral vasküler girişim sırasında (T2) ve işlem sonrası anne yanında iken (T3) olmak üzere dört farklı zamanda değerlendirildi.

Bulgular: Çalışmanın bulguları T0, T1 ve T2 zaman noktalarında ağrı düzeylerinde anlamlı farklar olduğunu ortaya koydu. Midazolam dozu ile ağrı algısı arasında anlamlı bir ilişki bulunmazken, ketamin dozu ile kardiyak kateterizasyon sonrası anne yanında ağrı düzeyi (T3) arasında istatistiksel olarak anlamlı bir ilişki tespit edildi.

Sonuç: Etkili sedasyon planlaması, çocukların deneyimlediği ağrı derecesinin anlaşılmasını gerektirir. Bu çalışma, lokal anestezi ve prosedürel sedasyon almasına rağmen hastaların hâlâ rahatsızlık hissedebileceğini göstermiştir. Bu durum, kardiyak kateterizasyon sırasında konforu artırmak için ağrı yönetimi stratejilerinde daha fazla iyileştirme yapılması gerektiğini vurgulamaktadır.

Anahtar Kelimeler: Kardiyak kateterizasyon, ağrı algısı, deri iletkenlik aktivitesi ölçümü

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Various methods are currently used to assess pain perception. Behavioral responses, such as changes in sleep-wake patterns, crying, body, arm and leg movements, and facial expressions, are commonly employed for this purpose.[1] However, the diagnostic value of these methods is limited, as they can be influenced by factors other than

pain. Furthermore, they are not effective in patients who are too severely ill or sedated to exhibit behavioral responses. The specificity of pain assessment based on physiological indicators, such as changes in heart rate, respiratory rate, and oxygen saturation, is also relatively low.[2]

Skin conductance activity, a non-invasive and highly sensitive method unaffected by environmental temperature or cardiorespiratory status, has been used to assess pain in both premature and full-term newborns.[3] The skin conductance activity method is based on measuring the response of the sympathetic nervous system, which involves the activation of palmar and plantar sweat glands in response to stress, as well as the psychogalvanic reflex. Skin conductance is assessed through the analysis of three parameters: the average skin conductance level, the number of skin conductance waves per second, and the amplitude of each skin conductance wave.

In this study, our aim was to identify pain perception associated with routine procedures during cardiac catheterization and to explore the possibility of making the procedure more comfortable based on the findings.

Materials and Methods

This study was designed as a prospective evaluation of pain perception in the catheter angiography laboratory among children with congenital heart disease. A total of 24 patients undergoing cardiac catheterization were included. Patient demographics, including age, gender, and body weight, along with echocardiographic and angiocardiographic diagnoses, procedure type, and duration were recorded. Given the multifaceted nature of pain, which cannot be directly measured and is influenced by factors such as anxiety, expectations, and cultural differences, we selected skin conductance activity as a more objective and feasible method for assessing pain perception. All patients underwent pain perception measurements using the Med-Storm Pain Monitoring System® (MED-STORM Innovation AS, Oslo, Norway). Measurements were taken at four distinct stages: before the procedure with the mother present (T0), during local anesthesia following general anesthesia (T1), during femoral vascular intervention (T2), and after the procedure with the mother present (T3). Local anesthesia was administered to the femoral access site prior to cardiac catheterization in all patients, using 1-3 mg/kg of lidocaine. This was followed by intravenous midazolam at a dose of 0.05 mg/kg and intravenous ketamine at the same dose. Anesthesia was subsequently maintained with 2% sevoflurane insufflation in oxygen via an oxygen mask. Patients who required additional sedation were excluded from the study.

In the measurement of skin conductance activity, the number of skin conductance fluctuations per second (NSCF) was quantitatively recorded, using a threshold of > 0.02 microsiemens (μS) to identify fluctuations in the perioperative environment. Data were continuously monitored and recorded on a laptop computer via a standard serial connection.[4,5] Informed consent was obtained from the families of all patients. The study was approved by the Gazi University Non-Interventional Clinical Research Ethics Committee (Approval Number: 123, Date: 21.03.2012) and conducted in accordance with the principles of the Declaration of Helsinki.

ABBREVIATIONS

ASD	Atrial septal defect
FLACC	Face, legs, activity, crying, consolability scale
NIPS	Neonatal Infant Pain Scale
NSCF	Number of skin conductance fluctuations per second
PDA	Patent ductus arteriosus

Table 1. Demographic Characteristics of the Patients

Variables	n = 24
Age (months)	53.3 ± 52.9
Female/Male	13/11
Weight (kg)	17.3 ± 13.0
Cyanotic/Acyanotic	7 (29.2%)/17 (70.8%)
Procedure Type	
PDA Closure	3 (12.5%)
ASD Closure	1 (4.2%)
Balloon Aortic Valvuloplasty	1 (4.2%)
Balloon Pulmonary Valvuloplasty	1 (4.2%)
Diagnostic Procedure	18 (75%)
Catheterization Duration (min)	39.5 (14-90)
Ketamine Dose (mg)	19.6 ± 8.3
Midazolam Dose (mg)	0.26 ± 0.14
Ketamine Dose per Kilogram (mg/kg/dose)	1.5 ± 0.6
Midazolam Dose per Kilogram (mg/kg/dose)	0.02 ± 0.01

ASD, Atrial septal defect; PDA, Patent ductus arteriosus.

Statistical Analysis

All statistical analyses were performed using SPSS software version 15.0 (SPSS, Inc., Chicago, IL, USA). The distribution of continuous and numerical variables was assessed for normality using the Shapiro-Wilk test.

Statistical significance regarding perceived pain levels across measurement stages was analyzed using the Friedman test. A P value of < 0.05 was considered statistically significant. In cases where the Friedman test indicated significance, the Bonferroni-adjusted Wilcoxon Signed-Rank test was applied to identify which stages contributed to the difference. Results were considered statistically significant at $P < 0.0083$ according to the Bonferroni adjustment.

The correlation between perceived pain levels at each observation time and variables such as age, procedure duration, and ketamine and midazolam dosage per kilogram was examined using the Bonferroni-adjusted Spearman's correlation test. Results were considered statistically significant at $P < 0.0125$, according to the Bonferroni adjustment. The statistical significance of perceived pain levels based on gender and cyanotic status at each observation time was assessed using the Bonferroni-adjusted Mann-Whitney U test, with $P < 0.0125$ considered significant. In this study, the Bonferroni adjustment was applied to control the Type I error rate in all multiple comparisons.

Table 2. Distribution of Patients by Catheter Angiography Diagnosis

Catheter Angiography Diagnosis	Number of Patients	Percentage
Patent Ductus Arteriosus (PDA)	8	33.3
Atrial Septal Defect (ASD, secundum)	4	16.8
Aortic Stenosis (valvular)	1	4.2
Atrioventricular Septal Defect	3	12.6
Transposition of the Great Arteries	1	4.2
Operative Endarterectomy/Superior Vena Cava Thrombosis	1	4.2
Pulmonary Stenosis (valvular)	2	8.4
Ventricular Septal Defect	1	4.2
Pulmonary Arteriovenous Malformation	1	4.2
Tetralogy of Fallot	2	8.4
Total	24	100

Table 3. Perceived Pain Levels by Procedure Stage

Measurement Period	Perceived Pain (μS)
T0	0.15 ± 0.18 (0.00–0.60)[b,c]
T1	0.45 ± 0.33 (0.03–1.13)[b]
T2	0.40 ± 0.40 (0.00–1.13)[c]
T3	0.26 ± 0.48 (0.00–1.47)
P[a]	<0.001

a, Friedman test; b, Statistically significant difference between T0 and T1 (P < 0.001); c, Statistically significant difference between T0 and T2 (P = 0.005).

Table 4. Correlation Coefficients and Significance Levels Between Per Kilogram Doses of Ketamine and Midazolam and Pain Levels Perceived by Patients at Each Stage

	Ketamine Dose		Midazolam Dose	
Measurement Period	r	P*	r	P*
T1	-0.069	0.755	0.054	0.802
T2	-0.104	0.638	-0.025	0.907
T3	-0.561	0.005	-0.441	0.031

*Spearman's correlation test. Results were considered statistically significant at P < 0.0125 (Bonferroni adjustment).

Results

The study included 24 patients, ranging in age from 50 days to 16 years. The demographic and clinical characteristics of the patients are presented in Table 1.

The diagnoses of patients undergoing catheter angiography are shown in Table 2.

The patients' pain perception scores across different stages of the catheter angiography procedure are summarized in Table 3. Compared to the period before the procedure with the mother present (T0), perceived pain levels were statistically significantly higher at stages T1 and T2 (P < 0.001 and P = 0.005, respectively). However, there was no statistically significant difference in perceived pain levels between T0 and T3 (P = 0.616). Additionally, perceived pain levels between stages T1 and T2 were statistically similar according to the Bonferroni adjustment (P = 0.059 and P = 0.163, respectively).

No statistically significant correlation was observed, based on the Bonferroni adjustment, between per kilogram midazolam dose and the pain levels perceived by the patients. However, an increase in the per kilogram ketamine dose was significantly associated with decreased pain levels at T3 (r = -0.561, P = 0.005) (Table 4).

There was no statistically significant difference in perceived pain levels at each stage based on gender (Table 5).

Furthermore, no statistically significant correlation was found between patients' age or procedure duration and the perceived pain levels, according to the Bonferroni adjustment (P > 0.0125) (Table 6).

Table 5. Perceived Pain Levels at Each Stage by Gender

Measurement Period	Male	Female	P[a]
T0	0.15 ± 0.15 (0.00–0.40)	0.14 ± 0.21 (0.00–0.60)	0.649
T1	0.54 ± 0.38 (0.10–1.13)	0.38 ± 0.28 (0.03–1.07)	0.459
T2	0.46 ± 0.42 (0.03–1.13)	0.34 ± 0.40 (0.00–1.03)	0.228
T3	0.49 ± 0.64 (0.00–1.47)	0.07 ± 0.10 (0.00–0.27)	0.252

a, Mann–Whitney U test. Results were considered statistically significant at P < 0.0125 (Bonferroni adjustment).

Table 6. Correlation Coefficients and Significance Levels Between Age, Procedure Duration, and Pain Levels Perceived by Patients

	Age		Catheterization Duration	
Measurement Period	**r**	**P***	**r**	**P***
T0	0.164	0.444	-0.009	0.965
T1	0.001	0.998	0.147	0.493
T2	0.114	0.595	0.180	0.401
T3	0.255	0.229	-0.002	0.992

*Spearman's correlation test. Results were considered statistically significant at P < 0.0125 (Bonferroni adjustment).

Discussion

Every child has an ethical right to have their pain alleviated, and healthcare interventions should address this need. However, studies continue to show that children often do not receive effective pain management services.[6] Moreover, untreated pain can have long-term negative effects on children's growth, development, and emotional well-being.[7]

Globally, there is no consensus on the assessment and management of pain. Pain experienced by children is a complex phenomenon, as it is inherently subjective.[8] Although numerous methods exist for assessing pain, no standardized approach offers both high sensitivity and specificity while remaining practical for routine clinical use. Children's anxiety, fear, and pain can be objectively assessed using physiological indicators such as heart rate, blood pressure, respiratory rate, and changes in oxygen saturation.[6] However, behavioral and physiological responses used for pain assessment are influenced by many factors other than pain and have limited diagnostic specificity.[9,10] Furthermore, these methods are not effective in children who are unable to respond to painful stimuli, such as those who are unconscious or sedated.[2,11] The use of physiological variables in pain assessment is not unexpected, as limited clinical practice guidelines suggest their use as indicators of pain in the absence of behavioral cues.[2,11] However, these parameters are not reliable under sedation or anesthesia.

To address this, skin conductance activity, a non-invasive and highly sensitive method that is unaffected by environmental temperature or cardiorespiratory conditions, is used for the objective assessment of pain in both premature and full-term newborns.[3,5]

Günther et al.,[12] in their study evaluating children in intensive care who were monitored using the Med-Storm pain monitoring system, found that pain perception increased during routine procedures. Similarly, in our study, it was observed that pain perception significantly increased during the application of local anesthesia (T1), but did not increase further during the femoral entry procedure performed after local anesthesia (T2). These findings emphasize the importance of local anesthesia in managing pain perception in patients with altered consciousness or under sedation.

In a study conducted by Pereira-da-Silva et al.[13] on newborns, using the Neonatal Infant Pain Scale (NIPS) and Med-Storm pain monitoring, it was demonstrated that pain levels during heel lance, blood gas, and blood glucose measurements were significantly higher during blood sampling compared to pre-procedural levels. However, unlike our study, their study did not include the use of local anesthesia or premedication.

In our study, it was also observed that as the per kilogram dose of ketamine increased, the post-procedure pain level with the mother present (T3) significantly decreased (r = -0.561, P = 0.005). This effect of ketamine was not observed at the T1 and T2 stages. No significant correlation was found between midazolam dose and the pain levels perceived by the patients. Based on this finding, we can conclude that ketamine is more effective than midazolam in reducing pain perception and improving patient comfort, particularly during the postoperative period when the child is next to the mother.

In conclusion, pain perception is a condition that children often cannot easily express and is frequently under unconscious control. Inadequate pain management can lead to various biopsychosocial effects in children, both in the short and long term.[14] In the short term, pain can cause additional stress, leading to increased heart rate, elevated blood pressure, greater myocardial oxygen consumption, delayed healing, and a weakened immune system.[14,15] Despite sedation during interventional procedures, pain perception can still be high. Therefore, we believe that, in addition to standard sedation practices, local anesthesia should be administered to reduce pain perception in patients prior to interventional procedures.

Limitations

The most significant limitation of our study is the small sample size, which necessitates further research with a larger cohort to validate our findings. Additionally, the wide age range among participants represents another limitation, as it may introduce variability in the results. Another notable limitation is the lack of evaluation of the effects of procedure type and duration on pain perception. Furthermore, since the use of larger or longer sheaths may potentially increase pain perception, the fact that sheath sizes were not recorded in our study constitutes an additional limitation. Due to the non-homogeneous distribution of study groups, drawing definitive conclusions regarding pain perception in cyanotic versus acyanotic patients may not be entirely reliable. Future research with larger sample sizes and more evenly distributed patient populations is needed to provide more robust and generalizable findings. Lastly, as there are no other studies similar to ours in the literature, it was not possible to compare our result with prior findings in detail.

Conclusion

Physiological variables such as heart rate, peripheral capillary oxygen saturation, crying intensity, and pain levels can be assessed using the Face, Legs, Activity, Crying, Consolability (FLACC) scale. However, these measurements may not yield meaningful results when patients are under sedation. To date, there is no universally valid method for assessing and managing pain in children undergoing cardiac catheterization. This study demonstrated that even with the use of local anesthetics and procedural sedation, patients may still experience discomfort. These findings highlight the need for further advancements in pain management strategies to enhance patient comfort during cardiac catheterization.

Ethics Committee Approval: Ethics committee approval was obtained from Gazi University Non-Interventional Clinical Research Ethics Committee (Approval Number: 123, Date: 21.03.2012).

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