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Original Article

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Managing SVT attacks in NICU: A single tertiary center experience

Abstract

Aim: This study aimed to assess the efficiency of adenosine and amiodarone in ceasing supraventricular tachycardia (SVT) attacks and enduring 1-hour attack-free period in neonates.
Materials and Methods: We included all SVT attacks detected in our NICU and recorded adenosine success in enduring 1-hour attack-free period, postnatal day, birth week, and clinical status. All patients underwent vagal maneuvers as the initial intervention; then, they were administered intravenous adenosine via a central line, the dose of which was increased from 0,05 mg/kg/dose up to 0.2 mg/kg/dose if the SVT attack persisted. We included each SVT attack separately.
Results: We observed 21 SVT attacks (gestational age 39.8+/-2.3 weeks) in 10 patients. There was a significant correlation between adenosine success and the postnatal day for SVT attacks (Kendall's tau b: 0.584, p=0.002). Multivariate analysis showed that the most effective confounder for adenosine success was the postnatal day [odds ratio 1.9 (%95 CI: 1.03-3.5) per day]. Intravenous amiodarone loading therapy aborted SVT attack in all adenosine-resistant patients.
Conclusion: Amiodarone infusion may be considered earlier in cases where there is a need for repeated adenosine, especially in the early neonatal period.

Keywords: Supraventricular tachycardia, newborn, amiodarone, adenosine

INTRODUCTION

Paroxysmal supraventricular tachycardia (SVT) is a common pediatric tachyarrhythmia problem with a 0.6% prevalence in the newborn period (1). Regarding all outpatient and inpatient children, SVT appears in 26% in the first month, 34% in the first three months, and 43% in the first year of life without statistical difference between genders (2).

Symptoms vary according to age, heart rate, and SVT duration, but congestive heart failure may occur if left untreated (2), which may even cause necrotizing enterocolitis by disrupting intestinal circulation (3-5). Hemodynamic stability is critical in determining the first-line treatment in SVT (6). Vagal maneuvers are the first option for SVT treatment if hemodynamic parameters are stable (2); however, emergency synchronized cardioversion is the first option if there are any signs of hypotension, unconsciousness, or prolongation of capillary filling time (6). Approximately half of the babies with an SVT attack need abortive treatment with adenosine, and 10% of these may require cardioversion (7). Synchronized cardioversion is successful in 60% of patients, where "overdrive atrial pacing" is efficacious in synchronized cardioversion-resistant attacks (2).

Medical treatments given in SVT attacks have two components. Abortive therapy is an acute intervention that increases the likelihood of eliminating arrhythmia or controlling heart rate, and secondary prevention is the prophylactic treatment to prevent SVT recurrence (7). Clinicians can use adenosine in acute therapy for aborting SVT at any age (6-8). The adenosine effect occurs after 10-20 seconds by creating an atrioventricular block after rapid bolus infusion (6,8), and its short half-life (<2 seconds) and minimal negative inotropic side effects are the advantages (8). The success of adenosine treatment ranges from 85% to 100%

(6), but due to its short half-life, the application method is critical (9). It should be applied with the fastest intravenous push from the most central vessel by using a stopcock, and following its administration, isotonic serum should be given immediately to abort the SVT attack (6).

8% of cases still need acute treatment afterward abortive treatment (7). For the acute pharmacological treatment of SVT, adenosine, propafenone, flecainide, amiodarone, procainamide (8), and digoxin (6) are options, but clinicians should use them cautiously to maintain normal rhythm in the neonatal period (6,8), where verapamil is not in use in children below one-year-old since it can cause irreversible electromechanical dissociation (10).

Prophylactic treatment is also critical, as SVT attacks typically discontinue after the age of one in most patients (2,11). Clinical centers may have different preferences (7), but most centers prefer beta-blockers and digoxin as initial drugs in prophylaxis (2), where flecainide, propafenone, and amiodarone are the other options (8). In some resistant cases, clinicians need multiple-drug therapy for prophylaxis (12).

There are factors described in the literature causing adenosine therapy failure, and one of these is a delay in SVT treatment (13). Although adenosine is not always 100% effective, it is the first-line medical therapy (13,14). As adenosine success rates vary in the literature, we wanted to assess the factors that may influence the success of adenosine in enduring a 1-hour attack-free period in newborns in this study, which might increase clinicians' awareness and follow-up regimen.

MATERIALS AND METHODS

In this retrospective study, we enrolled all patients treated in our neonatal intensive care unit (NICU) for any reason and had an SVT attack between January 2018 and January 2021. We used 12-lead electrocardiography for diagnosis.

We performed synchronized cardioversion to clinically unstable SVT attacks, but if the vital signs were stable, we applied vagal maneuvers first. If the SVT attack had not stopped, we administered adenosine starting with 0.05 mg/kg/dose via a central line. We gave two additional doses of adenosine of 0.1/mg/kg/dose and 0.2 mg/kg/dose if the SVT attack persisted. We used amiodarone with loading and maintenance doses, 5 mg/kg in one hour and 7 mcg/kg/min, respectively, if the SVT attack was adenosine-resistant. We accepted SVT abortion and its non-recurrence for at least one hour as treatment success and evaluated adenosine efficacy in this context (2).

We investigated a possible correlation between adenosine success and the gestational age at birth, birth weight of the patients, the postnatal day and postconceptional week of SVT attack, acute kidney injury, echocardiographic imaging, and the need for inotropic treatments and respiratory support (both non-invasive and invasive).

Istanbul University-Cerrahpasa ethical committee permission was obtained for this retrospective study (file number: 185 date: June 2022).

Statistical Analysis

We used R based open-source statistical package program Jamovi 2.0 for the statistical tests (13,14). Descriptive data with normal distribution were presented with mean±standard deviation, and non-normal distributed data were presented with median (25'th-75'th percentiles). We used Kendall's tau correlation test for assessing correlations, and chi-square and Fisher's exact test for comparing categorical variables.

First, we assessed variables that were significantly associated with the success of adenosine therapy ($p<0.1$) by "forward selection" and "stepwise method", and then we put these variables in a logistic regression model to identify the possible predictors. Type 1 error of <0.05 was accepted as statistically significant.

RESULTS

We included 21 SVT attacks on 10 patients in our NICU. The mean gestational week at birth was 39.8±2.3 weeks, and the median postnatal age was median 8 (6-12) days. We could not stop any SVT attacks with vagal maneuvers, but adenosine bolus therapy was successful in 71.4% (n=15) of them. Amiodarone infusion terminated all the SVT attacks in which adenosine therapy was not successful as acute treatment. The descriptive features are described in Table 1.

Table 1. Descriptive features of patients' SVT attacks

Postconceptual week at SVT attack	39.8±2.3
Postnatal day at SVT attack	8 days (6-12)
Adenosine success	71.4%
Ventricular septal defect	47.6%
Acute kidney injury	28.6%
Inotrope infusion	23.8%
Respiratory support need	52.4%

Data is presented as mean±sd, median (interquartile range), and %(n), SVT: supraventricular tachycardia

There was a significant correlation between postnatal day and adenosine success. The correlations table with possible confounders is described in Table 2.

Table 2. Correlations table for adenosine success

	Kendall's Tau B	p
Postconceptual week at SVT attack age	0.293	p=0.119
Postnatal day at SVT attack	0.584	p=0.002
Respiratory support need	-0.181	p=0.418
Ventricular septal defect	-0.182	p=0.466
Inotrope infusion	-0.39	p=0.08

There was a significant correlation between the postnatal day and adenosine success (n=21, R2McF: 0.467, χ^2=11.7, $p<0.001$) in the binomial regression test. The odds ratio for adenosine

success was 1.9 (95% CI=1.03-3.51, p=0.039) per day. The estimated marginal means graph (Figure 1) and table (Table 3) are presented. Postconceptional weak had a weak correlation with the first attack and was non-significant in the multivariate model.

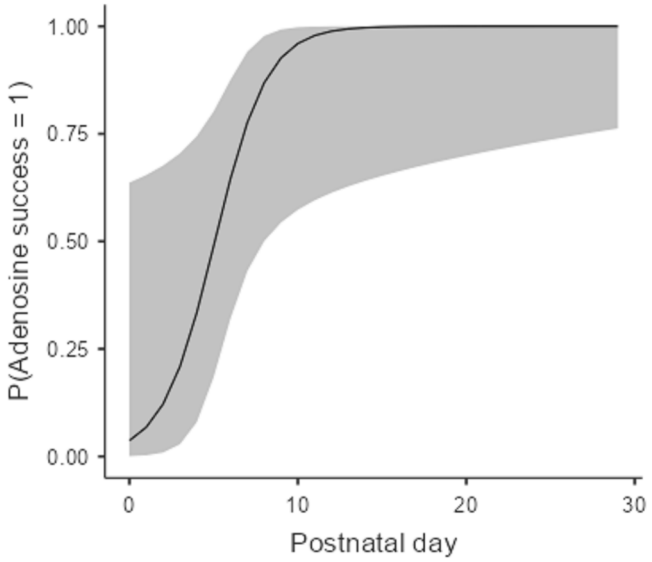

Figure 1. Estimated marginal means graph for postnatal day and adenosine success possibility on SVT attacks. P: Probability of adenosine success. Gray zone indicates 95% confidence interval

Table 3. Estimated marginal means table for postnatal day and adenosine success possibility on SVT attacks

Postnatal day	Estimated mean success rate (95% Confidence Interval)
1.78 days	10.8% (7.1%-67.1%)
10.19 days	96.4% (57.8%-99.8%)
18.6 days	99.0% (68.7%-100%)

CI: Confidence interval, P: Probability of adenosine success, (Gray zone indicates 95% confidence interval)

As we assessed adenosine success rate in terms of early and late neonatal periods, adenosine was not successful in the early neonatal period as it was in the late neonatal period in the first SVT attack (n=10, fisher's exact test, p=0.01) and total SVT attacks models (n=21, fisher's exact test, p<0.001).

Additionally, one patient had Wolf-Parkinson-White syndrome.

DISCUSSION

Neonatal arrhythmias are not seen very often (15), but they may cause severe life-threatening clinical outcomes in addition to and other than the arrhythmia itself (4,5).

Although the first treatment option in SVT is vagal maneuvers, its effectiveness in the neonatal period is controversial (2). Although it may cause severe cold panniculitis in newborns (16), it is generally harmless if performed carefully, as long as this does not cause a delay in medical treatment. Vagal maneuvers did not cease the SVT attacks in our NICU patients, though they did not encounter adverse effects.

Adenosine is usually the first drug of choice for abortive therapy of SVT attacks in all age groups (8), with an overall 77-80% success rate in aborting SVT attacks (13,14); however, SVT has a 57% recurrence rate in 3-month-old and younger infants after adenosine treatment (17). The failure rates may be due to being noticed late in this age group, where delayed treatment causes the SVT attack to become more likely to be refractory to adenosine bolus therapy (13). We used adenosine bolus therapy as the first-line medical treatment for aborting SVT in all attacks in our case series, which resulted in a 71.4% success, and we believe we noticed and intervened immediately without any delay.

We could not find any information about adenosine success and postnatal day correlation in the literature. In both SVT groups, we could not find adenosine as successful as it is in the late neonatal period compared with the early neonatal period. Also, adenosine success correlated with the postnatal day of the patient (Kendall's Tau b =0.584, p=0.002) in our study group. There was a significant correlation between the postnatal day and adenosine success in SVT attacks (n=21; odds ratio 1.9 [%95 CI: 1.03-3.51], R2McF: 0.467) in the binomial regression model. The odds ratio of adenosine success was 1.9 per postnatal day in all SVT attacks. We assessed that the need for respiratory support, ventricular septal defect presence, and inotropic drug need could be confounders. Yet none was a confounder for adenosine success in the binomial regression model (p>0.01).

Amiodarone hydrochloride is an ionized benzofuran derivative, chemically similar to L-thyroxine. It prolongs the action potential of cardiac fibrils and extends the effective refractory period in the auricula, atrioventricular node, ventricle, and accessory pathways (18). In the literature, amiodarone success in SVT suppression is up to 84-93% (19,20). Unlike adenosine, early recurrence of SVT is rare after amiodarone therapy (20). Furthermore, patients with congestive heart failure who were unresponsive to adenosine and cardioversion were treated successfully with amiodarone loading and maintenance treatment (21).

All our adenosine-resistant and one cardioversion-resistant SVT attacks successfully resolved after an amiodarone loading dose in our study. Amiodarone loading aborted all SVT attacks in which adenosine bolus infusion was unsuccessful. Amiodarone maintenance infusion dose of 7 mcg/kg/min maintained normal cardiac rhythm.

Although it is very effective, amiodarone is a reserve drug in refractory SVTs that does not respond to other anti-arrhythmic drugs since its side effect rate is high (8). Pulmonary fibrosis due to amiodarone treatment seen in adult patients is not common in children, but keratopathy, thyroid abnormalities, skin changes, hepatitis, and pulmonary fibrosis are the long-term side effects. Though it is safe for short-term use in newborns and infants (21), the incidence of side effects is reported between 8-29% at 28 months follow-up (8). We did not detect any of these adverse effects in the short term with amiodarone in our study group.

Some authors advocate amiodarone as the first choice, especially

in the infantile period (8), but there may be dose-independent side effects on thyroid functions (22). Hypotension also occurs more frequently in infants, so it is necessary to be careful in hemodynamically unstable infants (7). However, a study recommends electrical stimulation with the catheter if amiodarone therapy is unsuccessful because they assume that amiodarone is the last medical treatment option (20). Another research suggests that if anti-arrhythmic treatments with amiodarone and sotalol are ineffective or have intolerable side effects, radiofrequency catheter ablation is needed (23). Amiodarone infusion was effective in all patients. Although one patient needed the maximum infusion dose, none needed radiofrequency catheter ablation.

Two other main drugs used in the acute treatment of SVT are digoxin and beta-blockers (5,8). Digoxin has two prominent cardiac effects. The inotropic effect occurs by increased intracellular calcium ion concentration, and the electrophysiological effect arises by affecting the myocardium and the conduction system in the heart (24). Because of inconsistent effectiveness and late efficacy, digoxin use is controversial in the acute period. Also, accessory pathways may shorten the anterograde effective refractory period and worsen the clinic in pre-excitation syndromes such as Wolf-Parkinson-White syndrome (8,20). In addition, high doses and renal failure may cause digoxin toxicity (25) and may cause hypotension episodes (26). Propranolol may cause hypotensive attacks in acute SVT attack treatment like digoxin (5), but less (26).

We used adenosine and amiodarone for abortion and did not detect these adverse effects in our study. Interestingly, all cases in which the abortive effect of adenosine treatment was not successful were in the first postnatal week, and adenosine successfully stopped SVT and endured at least a one-hour attack-free period when these patients had recurrent SVT attacks in the late neonatal period.

Limitations of our study are its retrospective design nature and the limited number of cases. None of the patients underwent electrophysiologic research, as SVT did not recur under treatment. The etiology of SVT attacks remained unknown except for one patient with Wolf-Parkinson-White syndrome.

CONCLUSION

According to these findings, adenosine effectiveness in enduring a 1-hour attack-free period varies according to the postnatal day in the neonatal period, so clinicians should be ready for SVT recurrence after adenosine treatment. Amiodarone infusion may be considered earlier in cases where there is a need for repeated adenosine, especially in the early neonatal period.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
İstanbul University-Cerrahpasa Ethical Committee Approval file number: 185 Date: June 2022.

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