

## Research Article

# Management of Neonatal Supraventricular Tachycardias; A Single Center Experience

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### Abstract

**Objectives:** Emergent treatment of neonatal supraventricular tachycardia (SVT) is very crucial because it may lead to life threatening conditions. The aim of this study is to evaluate the neonatal SVTs.

**Methods:** Neonates, who were diagnosed with SVT between December 2014 and May 2018, were analyzed. Clinical findings, electrocardiogram (ECG) and echocardiography findings, 24-hour Holter ECG recordings and medications were evaluated.

**Results:** 46 over 1932 newborns were diagnosed with SVT. 76% of patients were common SVT with narrow QRS and short RP, 13% with Wolff-Parkinson-White syndrome, 4.3% with multifocal atrial tachycardia, 4.3% with atrial flutter, 2.1% with permanent reciprocating junctional tachycardia. Adenosine terminated SVT in 84.4% of the cases. Synchronized cardioversion was performed in 10.8% cases. Amiodarone and/or esmolol for acute treatment was used in 39.1%. Propranolol, digoxin, amiodarone, propafenone and flecainide were the drugs used for monotherapy or combination therapies.

**Conclusion:** In patients with initially unresponsive to standard dose of adenosine and under acute treatment with amiodarone and/or emolol continuous infusion, higher doses of adenosine (300-500 µg/gr/kg) is very effective. Amiodarone alone and in combination with flecainide seems safe and effective.

**Keywords:** Arrhythmia, neonates, outcome, supraventricular tachycardia, treatment

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Neonatal arrhythmias, which are not uncommon, may occur in neonates with a normal heart or in neonates with structural heart disease; and/or may be a consequence of various cardiovascular, systemic, and metabolic diseases.<sup>[1, 2]</sup> The incidence of neonatal arrhythmias is reported as 1-5%.<sup>[1, 3, 4]</sup> Neonatal arrhythmias are classified as benign and non-benign arrhythmias and have various clinical manifestations. Supraventricular tachycardia (SVT), ventricular tachycardia (VT), atrioventricular conduction disorders and genetic disorders such as long QT syndrome are classified as non-benign arrhythmias.<sup>[1, 4, 5]</sup> Supraventricular tachycardia is the most common non-benign tachycardia among neonates, and reentry tachycardia via accessory pathway is the most common SVT in neonates and infants.<sup>[6, 7]</sup>

Clinical manifestations of the tachycardia mainly depends on the heart rate and urgent diagnosis and accurate treatment is very crucial because the tachycardia may lead to life threatening conditions such as hypotension, heart failure and shock.<sup>[8]</sup> A regular heart rate of >220/beats per minute, absent or altered axis P waves, and a QRS complex with a duration of <0.08 ms (unless aberrant conduction is present) are the typical ECG findings of supraventricular tachycardia.<sup>[9]</sup> Treatment of SVT is classified into three: 1) Abortive treatment, 2) Acute treatment 3) Secondary prevention or prophylactic treatment to prevent recurrence.<sup>[10, 11]</sup> The aim of this study is to evaluate the newborns diagnosed with supraventricular tachycardia in means of diagnosis, treatment, and follow-up.

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## Methods

Patients, who were born after 36<sup>th</sup> gestational week and diagnosed with supraventricular tachycardia in the first month of life in the pediatric cardiology department of University of Medical Sciences, Van Training and Research Hospital between December 2014 and May 2018, were evaluated retrospectively. The age, gender, gestational age, body weight, length of hospital stays, electrocardiogram and echocardiography findings, 24-hour Holter ECG recordings, medications used for the treatment and the efficacy of the medications were evaluated.

Local Ethics Committee approved the study and it was conducted in accordance with Helsinki Declaration.

## Definitions

Treatments were classified and defined as follows:

**Abortive treatment:** Administration of intravenous adenosine or performing synchronized cardioversion at any time to terminate tachycardia immediately; **Acute treatment:** Administration of intravenous amiodarone or esmolol in the first day of diagnosis; **Prophylactic treatment:** Amiodarone or esmolol treatment after the first day of diagnosis or treatment with propranolol, digoxin, flecainide or propafenone at any time.

## Statistical Analysis

SPSS program version 21 (SPSS, Chicago, IL, USA) was used for statistical analysis. Frequency, median, mean and distribution width were used for descriptive analysis.

## Results

### Demographic Features

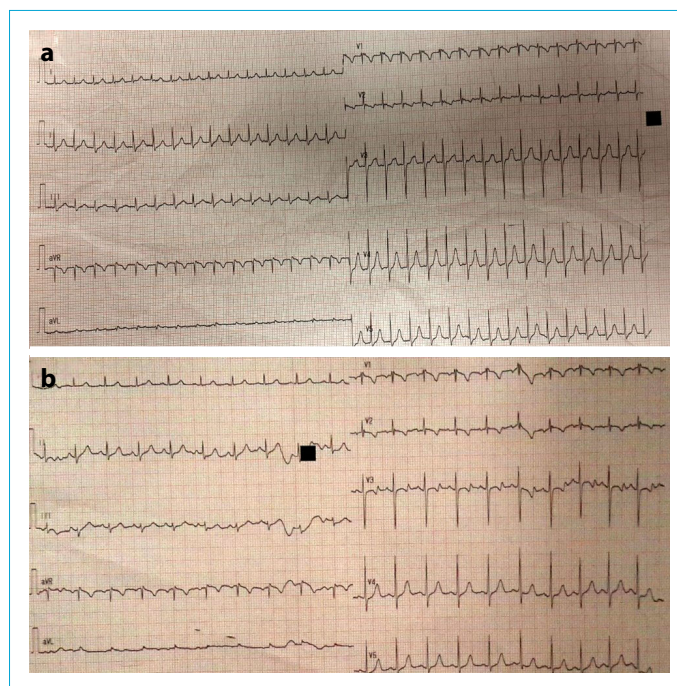
One thousand-nine hundred-thirty-two newborns were admitted to our department during the study period and 46 (2.3%) of them were diagnosed with SVT. Eight (17.4%) of these patients had admitted directly to our outpatient clinic due to any complaint, whereas 30 (65.2%) patients were referred to pediatric cardiology department from other departments of our institution and 8 (17.4%) were referred to us from other institutions. The mean gestational age, the mean age at the time of diagnosis and the mean body weight were  $38.04 \pm 1.20$  weeks (36–40 weeks and 4 days),  $16.63 \pm 7.61$  days (0–28 days) and  $3.46 \pm 0.44$  kg (2.8–4.2 kg), respectively. Three (6.5%) of the cases had fetal tachycardia without any findings of hydrops fetalis. 58.7% (n=27) of the cases were male and 41.3% (n=19) were female. Supraventricular tachycardia was recorded with 12 lead ECG in 43 (93.47%) and with 3 lead ECG monitor in 3 (6.53%) patients. The mean heart rate during the

SVT episode was  $236.95 \pm 20.94$  (220–300 beats/min) beats/min. 28 (60.8%) of the cases had no underlying structural heart disease, and the distribution of accompanying heart diseases were as follows: Atrial septal defect (ASD) 21.7% (n=10), patent ductus arteriosus (PDA) after 72 hours of life 6.5% (n=3), Ventricular septal defect (VSD) 6.5% (n=3), tricuspid atresia 2.1% (n=1), corrected transposition of great arteries (c-TGA) 2.1% (n=1). Five (10.8%) patients had mechanical ventilation support. Ten (21.7%) patients had clinical findings of congestive heart failure at the time of diagnosis and additional treatment for heart failure were given such as milrinone, diuretics and ACE inhibitors. Additionally, echocardiography of these patients revealed severe atrioventricular (AV) valve insufficiency in all and systolic dysfunction in 6 (13.0%) patients. Regarding the type of supraventricular tachycardia, 35 (76%) were common SVT with narrow QRS and short RP (probably AV re-entry tachycardia) (Fig. 1), 6 (13%) with Wolff-Parkinson-White syndrome (Fig. 2), 2 (4.3%) with multifocal atrial tachycardia (MAT) (Fig. 3), 2 (4.3%) with atrial flutter (Fig. 4), 1 (2.1%) with permanent reciprocating junctional tachycardia (PJRT) (Fig. 5).

## Treatment

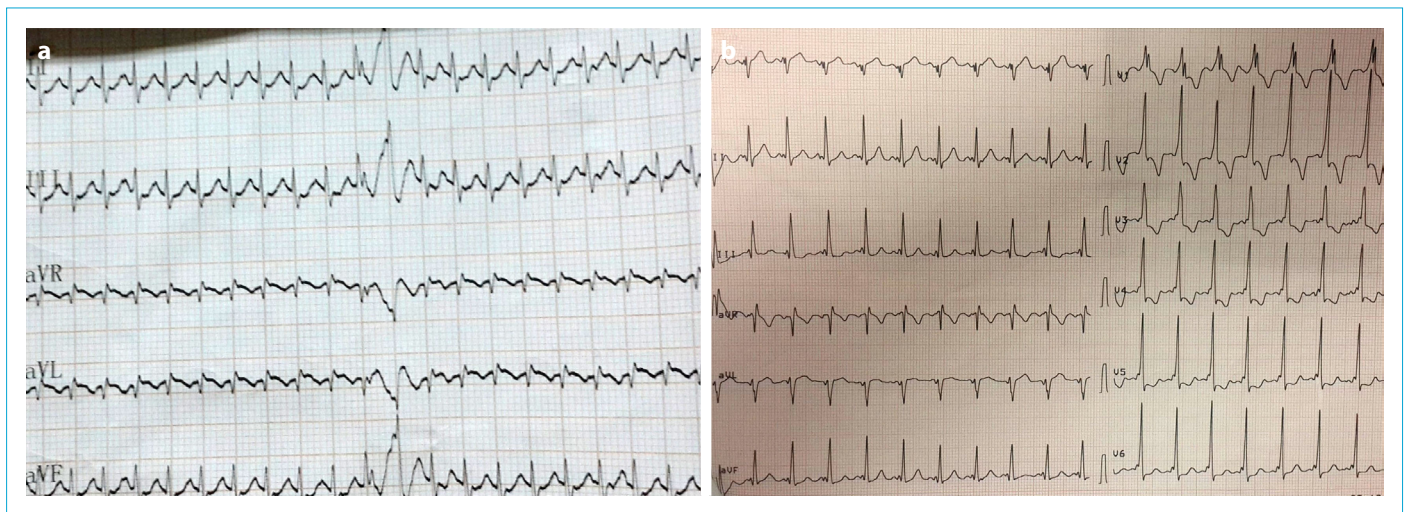
### Abortive treatment:

Adenosine was the first drug of choice for abortive treatment; but in patients, who admitted to our outpatient clinic and did not have intravenous access, ice pack was

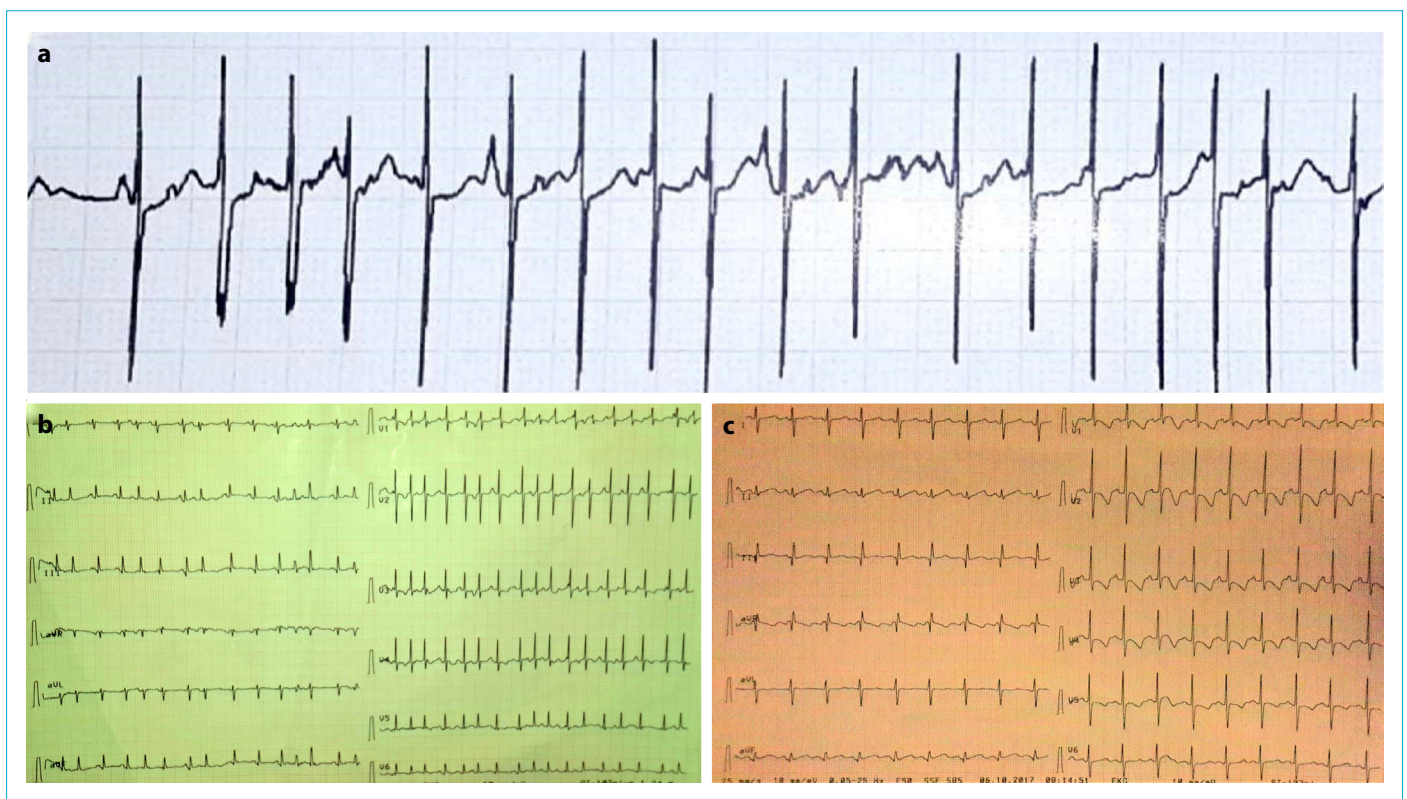


**Figure 1 (a, b).** ECG records of a 14 days old female patient during SVT with narrow QRS (a) and after abortive treatment (b) with adenosine.





**Figure 2 (a, b).** ECG records of a 20 days old male patient with WPW. **(a)** SVT episode, **(b)** pre-excitation findings occurred after termination of SVT.

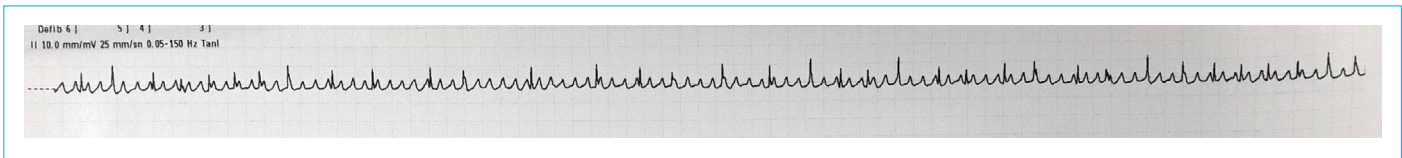


**Figure 3 (a-c).** ECG records of a 4 days old male patient. **(a)** 3-lead record of first tachycardia episode; **(b)** 12-lead record under prophylactic treatment with digoxin, propranolol and propafenone; **(c)** 12-lead record after prophylactic treatment with flecainide and amiodarone.

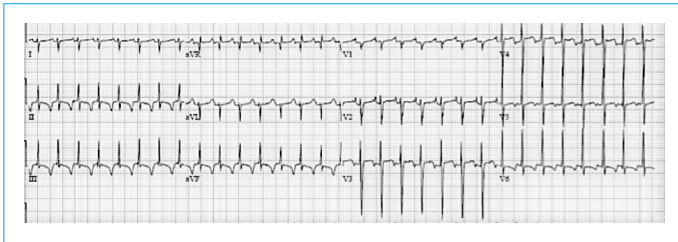
applied to face until obtaining an intravenous access. Ice pack was applied to a total of 4 (8.6%) patients. Two of them (50%) had no response to ice pack apply while the SVT terminated without recurrence in one (25%), and the SVT was terminated but there was a rapid recurrence in the other (25%). As a result, 3 of these patients were administered adenosine. Adenosine was used in a total of 45 (97.8%) cases for abortive treatment with an initial dose of

100-500  $\mu\text{g}/\text{gr}/\text{kg}$ , and in 38 (84.4%) of the cases the SVT terminated (Fig. 7). SVT recurred after a short period of time in 10 (26.3%) of these cases, whereas there was no recurrence in 28 (73.7%) cases. 5 (11.1%) cases had SVT that was refractory to adenosine even though maximal dosage (6 mg). However, in two of these patients with initially unresponsive SVT to adenosine and under acute treatment with amiodarone continuous infusion, higher initial doses of

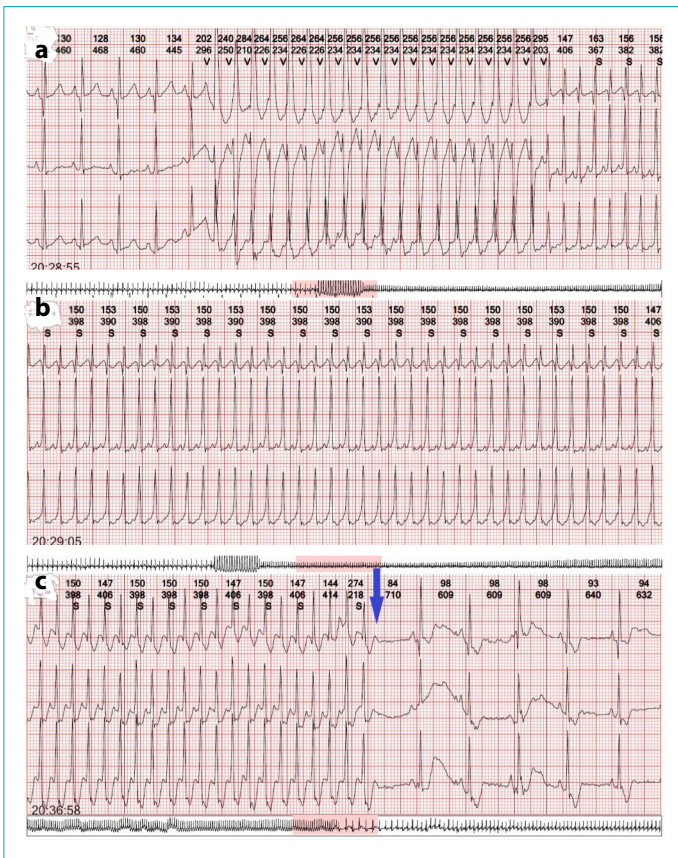




**Figure 4.** 3-lead-ECG record of a 12 days old male with atrial flutter.



**Figure 5.** ECG record of a 6 days old female diagnosed with PJRT.

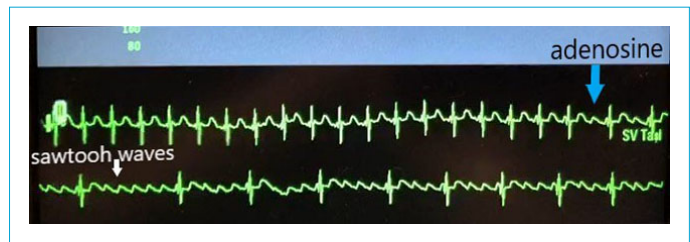


**Figure 6 (a-c).** 24-hours-Holter ECG record of a 26 days old male patient under 2nd day of acute treatment with amiodarone, showing a sustained tachycardia attack. Note that the tachycardia begins with wide QRS tachycardia followed by a narrower QRS tachycardia pointing co-occurrence of antidromic and orthodromic AVRT in same patient (a, b). This patients SVT initially was unresponsive to adenosine but a single high dose of (350 µg/gr/kg) adenosine terminated the SVT (c).

adenosine (300-500 µg/gr/kg) for recurrent SVT episodes were effective so SVT episodes were completely aborted (Fig. 6c). In two cases (4.4%) adenosine administration unmasked the underlying atrial flutter by causing rapid AV



**Figure 7.** A narrow QRS tachycardia terminating by adenosine administration in a 21 days old female patient.



**Figure 8.** 3-lead-ECG record of a female patient just after cesarean section who was diagnosed with fetal SVT. Adenosine unmasked the underlying atrial flutter and typical sawtooth waves occurred.

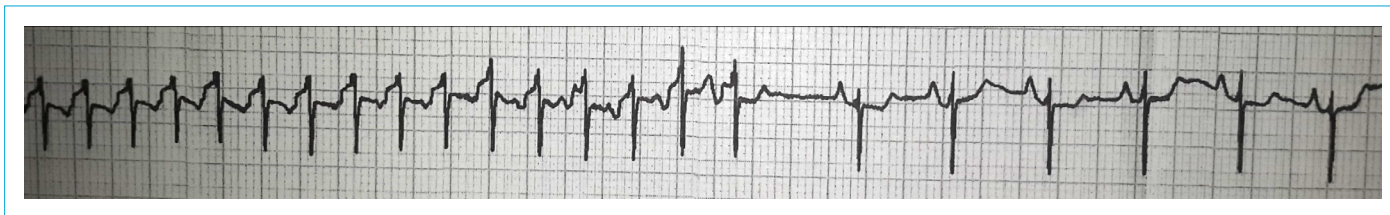
block (Fig. 8). Synchronized cardioversion was performed in 5 (10.8%) cases and in 4 (80%) of these the tachycardia terminated (Fig. 9), two of whom were atrial flutter.

**Acute treatment:**

Monodrug or combination therapy for acute treatment of SVT was used in a total of 18 (39.1%) cases, who had long lasting SVT and/or congestive heart failure symptoms or whose tachycardia did not terminate completely with adenosine. Amiodarone (86.6%), followed by esmolol (40%), was the most commonly used drug for acute treatment. Intravenous amiodarone and esmolol were used as monodrug in 11 (23.9%) and 2 (4.3%) of the cases, respectively. Intravenous amiodarone and esmolol were used in combination in 4 (8.6%) of the cases, and amiodarone, esmolol and digoxin were used in combination in 1 case (2.1%).

**Prophylactic treatment:**

Monodrug therapy and combination therapy was used for prophylactic treatment in 84.7% (n=39) and 15.3% (n=7) of the cases, respectively. Propranolol (76.9%), followed



**Figure 9.** 3-lead-ECG record of an 8 days old female patient with SVT unresponsive to adenosine. Cardioversion terminated the SVT.

by digoxin (23.1%), was the drug of choice for monotherapy. Propranolol and digoxin were used in combination in 4 (8.6%) cases. A combination therapy of digoxin, propranolol and propafenone was used in 2 patients and in one of these cases the treatment was switched to flecainide and amiodarone combination during follow-up. Propranolol, amiodarone and flecainide combination was used in one patient.

### Follow-up

The mean duration of hospital stay was  $4.91 \pm 2.48$  days (2-14 days). The mean duration of follow-up after acute treatment was  $18.76 \pm 12.52$  (1-42 months, median: 18.5 months) months. There was no recurrence of SVT during this period in 84.7% (n=39) of the cases. One case, who was diagnosed as multifocal atrial tachycardia, had another tachycardia episode at the first month of follow-up; so combination treatment with digoxin, propranolol and propafenone was switched to amiodarone and flecainide combination. There was no recurrence of tachycardia during a follow-up period of 6 months. Another case, who was using digoxin, propranolol and propafenone combination as prophylaxis for permanent junctional reciprocating tachycardia (PJRT), had an ablation therapy in another institution at the age of 5 months. The medications were decreased sequentially in patients receiving combination therapy if there was no tachycardia episode for at least 6 months. A total of 3 cases were taking 2 drug combination therapy (propranolol and digoxin combination in 2 cases; amiodarone and flecainide combination in 1 case), whereas none had 3 drug combination therapy after the age of 1 year. In 67.5% of the cases using monodrug for prophylaxis, the medication was discontinued after a follow up period of 6-12 months. There was recurrence of the SVT in 2 (5.4%) of these cases after the discontinuation of the medication. Propranolol was administered to these patients for prophylaxis and there was no recurrence of the SVT after.

### Discussion

The frequency of SVT in newborns is 1/200-250.<sup>[12]</sup> The incidence of SVT in newborn period was reported as 0.7% in a study conducted in our country.<sup>[13]</sup> In our study, the frequency of SVT in newborns admitting to our department

and in all neonates admitted to our institution was 2.3% and 1.07%, respectively. Although most newborns with SVT are asymptomatic, heart failure may occur in long lasting cases and very rarely SVT may be life-threatening.<sup>[14]</sup> Gilljam et al.<sup>[15]</sup> reported the mean age at the time of diagnosis of SVT as 1 day (1-30 days) and the mean heart rate during SVT episode as  $270 \pm 27$  beats/min. In this study conducted with 109 newborns, 52 (48%) of the cases had congestive heart failure at the time of admission. In our study, the mean age at the time of diagnosis was  $16.63 \pm 7.61$  days and the mean heart rate during SVT was  $236.95 \pm 20.94$  beats/min. 21% of the cases had findings of congestive heart failure at the time of admission and all disappeared after 48 hours of accept one whose heart failure symptoms completely disappeared after 6 days of treatment. Five (10.8%) patients had mechanical ventilation support.

Patients with accompanying congenital heart diseases such as Ebstein anomaly, c-TGA and single ventricle are at risk for SVT.<sup>[14, 16]</sup> The incidence of congenital heart disease in newborns diagnosed with SVT is reported as 6.5%-37%.<sup>[12, 13, 17-19]</sup> In our study, frequency of structural heart disease was 39.2%. In decreasing order of frequency, the accompanying heart diseases were as follows: ASD (21.7%), PDA (6.5%), VSD (6.5%), c-TGA (2.1%) and tricuspid atresia (2.1%).

Appropriate and acute management of SVT in children is crucial. Application of icepack to face for 5 seconds is effective and safe in patients with hemodynamically stable SVT.<sup>[20, 21]</sup> Adenosine is a nucleoside with a very short half-life and it restores normal sinus rhythm by blocking conduction through AV node.<sup>[22-24]</sup> It is the first drug of choice for abortive treatment in all types of SVT except atrial flutter in which the first choice of treatment is synchronized cardioversion.<sup>[22, 25]</sup> In addition, it has diagnostic importance in atrial flutter which is not AV node dependent. Unresponsiveness to adenosine is mostly related to inappropriate dosage, administration or vascular route. Etheridge et al.<sup>[26]</sup> reported that, SVT terminated spontaneously in 5 (15.6%), with vagal maneuvers in 3 (9.4%), and with application of icepack to the face in 1 (3.1%) of 32 newborns. In the same study, adenosine was successful in 14 (43.8%) of the cases and 9 (28.1%) of the cases required more than one medication for termination of SVT. In our study, icepack was



applied to 4 (8.6%) patients. In two of these cases the SVT terminated but in one patient there was rapid recurrence of SVT; whereas two patients had no response to icepack. Adenosine was administered to a total of 45 (97.8%) cases; and the SVT terminated in 38 (84.4%) cases but in 10 (26.3%) of these cases there was a rapid recurrence of the SVT. In first years of this study we had administered adenosine with an initial dose of 50-100  $\mu\text{g}/\text{gr}/\text{kg}$  as normally recommended but with our rising clinical experience we saw that initial doses under 200  $\mu\text{g}/\text{gr}/\text{kg}$  seem to be less effective in neonatal period. After that we started with an initial dose of 200-300  $\mu\text{g}/\text{gr}/\text{kg}$  for initial administration with much better responses. In some patients with initially unresponsive SVT to adenosine and under acute treatment with amiodarone continuous infusion, higher initial doses of adenosine (300-500  $\mu\text{g}/\text{gr}/\text{kg}$ ) for recurrent SVT episodes were administered and SVT episodes were completely aborted.

Synchronized cardioversion at 0.5 to 1 joule/kg is the treatment of choice in patients with hemodynamically unstable SVT and in patients with SVT that is refractory to medical treatment.<sup>[24]</sup> In our study synchronized cardioversion had been performed in 5 (10.8%) cases; and the SVT was terminated in 4 (80%) of them where two of them were atrial flutter. Cardioversion is usually ineffective in atrial and multifocal atrial tachycardias which are due to enhanced automaticity.

Group 1a, 1c and 3 anti-arrhythmic drugs including especially esmolol, procainamide, propafenone, flecainide, amiodarone, sotalol, are used for the acute treatment of SVT in patients, in whom the sinus rhythm cannot be obtained with adenosine or synchronized cardioversion.<sup>[27-29]</sup> In a large multicenter study, amiodarone (80%), followed by procainamide (20%), was reported as the most commonly used drug for the acute treatment SVT.<sup>[10]</sup> Esmolol, which is a rapid acting beta blocker with a short half-life, is reported to be effective in 63% of newborns with SVT.<sup>[30]</sup> Katipoğlu et al.<sup>[13]</sup> reported that esmolol was effective in 2 (66.7%) of the 3 cases, who were unresponsive to adenosine treatment. In our study, the individual efficacy of amiodarone and esmolol was 75.8% and 63.2% respectively. In addition to this, amiodarone and esmolol were used in combination for acute management of SVT in 5 (10.8%) and efficacy of this combination for acute treatment were 80%. Whereas in one patient this combination therapy was failed and digoxin was added as a third drug.

Beta blockers and digoxin are the most commonly used drugs for long lasting prophylactic treatment. While there is a reduction in the usage of digoxin, beta blockers became the first line agent for prophylaxis.<sup>[31]</sup> Medications such as amiodarone, flecainide and sotalol are used as a part of

combination therapy rather than monodrug therapy.<sup>[11, 31]</sup> In PHIS study, it was reported that second line drugs were used in 44% of the infants and 45% of the patients required multi drug therapy at the time of discharge. The most commonly used combination is beta blocker and digoxin combination, followed by combination therapies involving amiodarone.<sup>[10, 31]</sup> Gilljam et al.<sup>[15]</sup> reported that most of the newborns had antiarrhythmic treatment for 6-12 months after the last SVT episode. In our study, 84.7% of the cases (n=39) were given monodrug and 15.3% of the cases (n=7) were given combination therapy for prophylaxis. Propranolol (76.9%), followed by digoxin (23.1%), was the drug of choice for monodrug prophylaxis. Propranolol and digoxin were used in combination in 4 patients (8.6%).

A combination therapy of digoxin, propranolol and propafenone was used in 2 patients and in one of these cases the treatment was switched to flecainide and amiodarone combination during follow-up. Propranolol, amiodarone and propafenone combination was used in one patient and there after propafenone was switched to flecainide in the same combination. Although we generally added flecainide as the last choice of combination therapies, after good results and seeing no side effects with this drug, nowadays we think to use it as second line therapy in combination with amiodarone.

Prophylaxis were continued at least for 6 months after the last SVT episode. There was no patient requiring 3 drug combination therapy after the age of 1 year, but 3 (6.5%) patients were using combination therapy for prophylaxis. One (2.2%) of them was using amiodarone and flecainide, and the other 2 (4.3%) were using propranolol and digoxin combination for prophylaxis. The medication was discontinued in 64.1% (n=25) of patients using single drug for prophylaxis after a follow up period of 6-12 months. There was recurrence of the SVT in 2 of these cases after the discontinuation of the medication. Propranolol was administered to these patients for prophylaxis and there was no recurrence of the SVT after. There was no side effect related to drug therapy during follow up.

Neonatal tachycardias rarely require ablation therapies. Although 3-dimensional electroanatomical mapping methods reduces risks and exposure to radiation, the risks in patients under 15 kg in weight is still high. Ablation therapy is indicated as class 1A in patients who tachycardiomyopathy have developed and unresponsive to medical therapy. In our study only one patient underwent to ablation therapy.

In some studies, mortality due to supraventricular tachycardia has been reported.<sup>[13, 15]</sup> In a multicenter study, which included 1755 cases, the mortality rate due to SVT in chil-

dren was reported as 4%. The mortality rate was higher in patients with congenital heart disease and cardiomyopathy, and most of the patients without structural heart disease were infants.<sup>[32]</sup> In our study there was no mortality due to SVT.

## Conclusion

Supraventricular tachycardia may lead to cardiac failure and cardiovascular collapse; and it is an important cause of morbidity and mortality in newborns. Adenosine is the first-line treatment with high efficacy and safety. Initial doses of adenosine lower than 200 µg/kg seem to be less effective in neonates so we recommend to start with an initial dose of at least 200 µg/kg for abortive treatment of neonatal SVTs. In patients with initially unresponsive SVT to adenosine and under acute treatment with amiodarone and/or emolol continuous infusion, higher doses of adenosine (300-500 µg/gr/kg) is very effective for aborting recurrent SVT episodes. Amiodarone alone and in combination with flecainide is very safe and effective for long lasting prophylactic treatment of neonatal SVTs. Curative ablation for SVT may be a therapeutic option in very rare cases in whom the tachycardia cannot be controlled with multidrug treatment. Multicenter studies with larger number of cases are needed to increase our knowledge about the supraventricular tachycardias occurring in newborn period.

## Disclosures

**Ethics Committee Approval:** The study was approved by the Local Ethics Committee.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

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