Amiodarone Versus Procainamide for the Acute Treatment of Recurrent Supraventricular Tachycardia in Pediatric Patients

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Background—Intravenous amiodarone and procainamide are both used as therapies for refractory supraventricular tachycardia (SVT). However, no studies have compared the efficacy and safety of these agents in pediatric patients.

Methods and Results—All patients treated with intravenous amiodarone or procainamide during 25 consecutive months for the following mechanisms of SVT were included: orthodromic reciprocating tachycardia, intra-atrial reentrant tachycardia, and ectopic atrial tachycardia; junctional ectopic tachycardia was excluded. Treatment response was categorized as full success, partial success, or failure. Partial success was defined as clinical improvement and/or arrhythmia control but not meeting full success criteria. Adverse events were classified as major (requiring resuscitation) or minor (management changes). There were 40 episodes of SVT in 37 patients (median age, 34 days; 24 with congenital heart disease). Amiodarone was the initial therapy in 26 cases and procainamide in 14 cases. If partial and full success are combined, procainamide was successful in 71% of cases compared with 34% for amiodarone (P = 0.046). If partial success is considered a treatment failure, procainamide was successful in 50% compared with 15% for amiodarone (P = 0.029). Ten patients received the second medication after the first failed. Success was achieved in 5 of 8 amiodarone-to-procainamide crossovers compared with 1 of 2 procainamide-to-amiodarone crossovers. One major and 10 minor adverse events occurred in amiodarone patients versus 6 minor adverse events in procainamide patients (P = NS).

Conclusions—In this cohort, procainamide achieved greater success compared with amiodarone in the management of recurrent SVT without statistically significant differences in adverse event frequency. (Circ Arrhythm Electrophysiol. 2010;3:134-140.)

Key Words: antiarrhythmia agents • congenital heart defects • pediatrics • tachyarrhythmias

Supraventricular tachycardia (SVT) is a common problem in pediatric patients. Although relatively well tolerated in most, SVT may impose significant hemodynamic compromise in children who have recently undergone cardiac surgery or those who have abnormal ventricular function. Although SVT is often terminated with vagal maneuvers, adenosine administration, or cardioversion, tachycardia may be recurrent, requiring more complex management decisions in some cases.

The management of recurrent SVT is highly variable and depends on the arrhythmia mechanism, the underlying heart disease, and personal experience. Although invasive measures exist to obtain reasonable rate control of arrhythmias or convert patients back to a normal rhythm, antiarrhythmic medications are usually the mainstay of acute arrhythmia management. In recurrent or refractory SVT, both intravenous amiodarone and procainamide have been administered, with variable success rates reported in the literature.1–8 No studies to date, however, have compared these 2 medications in terms of efficacy and safety in the treatment of pediatric patients with SVT. The purpose of this study was to (1) compare the treatment efficacy of amiodarone versus procainamide in pediatric patients with recurrent SVT and (2) compare the adverse effects associated with the use of these 2 medications.

Materials and Methods

The study was based on a retrospective review of all intravenous amiodarone and procainamide administrations for the treatment of SVT at a single institution from July 1, 2004, to August 1, 2006. Study initiation coincided with the implementation of an electronic medical record system for medication documentation, allowing a query of all procainamide and amiodarone administrations during the time period of the study. Approval for this project was obtained from the hospital institutional review board.
Inclusion and Exclusion Criteria
A chart review of patients who received amiodarone and/or procainamide was performed to confirm that the medication was used to treat SVT, with the following arrhythmia mechanisms included (1) orthodromic reciprocating tachycardia (ORT) caused by manifest or concealed accessory AV connections, (2) intra-atrial reentrant tachycardia (IART) including atrial flutter, and (3) ectopic atrial tachycardia (EAT) with either a single or multiple foci. There were no patients treated with these medications that had either atrial fibrillation or documented atrioventricular nodal reentrant tachycardia during the study period.

Patients without ECG documentation of SVT were excluded. Patients with ventricular arrhythmias and those who received procainamide as part of an electrophysiological workup (ie, procainamide challenge to elicit ECG changes suggestive of Brugada syndrome) were also excluded from the study group.

Patients with junctional ectopic tachycardia (JET) were not included in this study. Amiodarone is the primary treatment of JET at our institution, with procainamide reserved for persistently refractory cases. Inclusion of cases of JET would have introduced a significant selection bias, thereby compromising a comparison of the 2 medications for these patients.

Data Collection
Progress notes and intensive care data sets were reviewed to collect the following: patient age at time of medication administration, sex, the presence of congenital heart disease, history of cardiac surgery, and hourly heart rate and blood pressure measurements. The SVT mechanism was recorded as well as the highest heart rate before administration of medication, the total number of episodes and recurrences, other modalities used for arrhythmia treatment, and adverse events (AEs).

Definitions
Treatment response was divided into three categories: immediate conversion, late conversion, and persistence of arrhythmia. Immediate conversion was defined as a rhythm change within 60 minutes from the start of administration of either medication. For ORT and IART, the rhythm change required a conversion to sinus rhythm. For EAT, the rhythm change was defined as a rate reduction of at least 20% compared with the rate before medication initiation with an absolute heart rate of <180 beats per minute. Late conversion was defined as the change occurring beyond 60 minutes but within 4 hours after therapy initiation and without the need for additional doses of the medication. Persistence was defined as the continuation of SVT or immediate recurrences despite administration of either medication.

Treatment efficacy was classified into 3 categories: full success, partial success, and failure. Definitions for success varied depending on the mechanism of SVT. For EAT and ORT, full success was defined as immediate conversion (within 60 minutes) without further recurrences. Patients with subsequent recurrences were still classified as full success if the following criteria were met: (1) recurrences only occurred when the patient was not receiving the medication and (2) immediate conversion was achieved for each recurrence on medication readministration. Full success for IART was also defined as immediate conversion without further recurrences. In addition, full success was also defined as absence of recurrences following initiation of antiarrhythmic medication in patients who previously had multiple episodes of IART, independent of the modality used for rhythm termination (rapid atrial pacing, DC cardioversion, or chemical cardioversion), thereby demonstrating a prevention of recurrences.

Partial success was defined as a response in which full success criteria were not met, but arrhythmia control and overall clinical improvement of the patient were still achieved. For ORT and EAT, this designation included patients started on continuous infusion therapy who achieved immediate conversion but developed recurrences over a 24-hour period, with all recurrences being immediately converted with additional boluses with or without drip augmentation. Additionally, patients who achieved late conversion and did not have further recurrences while on the medication were included in the partial success category. For cases in which a single episode of IART was cardioverted by rapid atrial pacing or DC cardioversion and no further recurrences were seen after antiarrhythmic therapy was prophylactically started, a partial success was assigned due to inability to conclude if recurrences would have occurred without the medication.

AEs were subdivided into major and minor groups. The distinction between the 2 groups was based on the response to the event. Major AEs were life-threatening events that led to emergent resuscitative efforts. Minor AEs were defined as events thought to be related to the medication administration that resulted in a change in clinical management such as the discontinuation of the antiarrhythmic agent, administration of intravenous fluids, or adjustment of inotropic infusions. Hypotension and bradycardia were considered related to the medications if an acute decline in either measure required intervention within 2 hours of the medication bolus or while on a continuous infusion and not attributable to other causes. Minor AEs also included ECG changes, which were defined as changes on ECG tracings that were not present before medication administration and not attributable to underlying cardiac disease or other medications.

Statistics
The Microsoft Excel Statistical Package was used for data analysis. Continuous data are summarized as medians (limits) with categorical data expressed as percentages (ratio). Wilcoxon rank-sum analysis was used to evaluate all continuous data with the Kruskal Wallis test used for 3-group comparisons. χ² analysis was used for categorical variables with Fisher exact analysis used for variables with cell counts <5. A probability value of ≤0.05 indicated statistical significance. The primary analysis used an “intention to treat” model and only included data from the first administered medication (amiodarone or procainamide) for any given episode.

Results
Patient Characteristics
During the study period, procainamide was administered to a total of 50 patients and amiodarone to 158 patients. Of these, 37 patients met the defined inclusion criteria. There were 20 boys and 17 girls with a median age of 34 days at the time of therapy initiation. Congenital heart disease was present in 24 patients (13 with univentricular physiology). A total of 40 distinct episodes of recurrent SVT occurred among the 37 patients. One patient had 2 different mechanisms of SVT and was treated during 3 separate hospitalizations; another patient was treated for the same SVT subtype on 2 separate hospitalizations, thus accounting for the 3 additional episodes relative to the total number of patients. Amiodarone was the initial therapy in 26 episodes, whereas procainamide was initially used in 14 episodes. Table 1 summarizes the baseline patient characteristics for each group. Patients initially treated with amiodarone were younger and had a higher incidence of congenital heart disease and postoperative arrhythmias. EAT was more prevalent among patients treated with procainamide compared with those treated with amiodarone.

Of the 40 episodes of SVT, 18 were IART, 11 were ORT, and 11 were EAT (Table 2). Congenital heart disease was more likely in ORT and IART patients compared with those with EAT (P = 0.007). ORT and IART patients also tended to be younger than the EAT patients (P = 0.088).

The median dose of amiodarone administered at medication initiation was 2.5 mg/kg (1 to 10 mg/kg). For procainamide, the median dose was 10 mg/kg (3.5 to 10 mg/kg).
After initial loading, amiodarone was administered as a continuous infusion in 14 of 26 patients (54%) at a median dose of 5 μg·kg⁻¹·min⁻¹ (2.5 to 15 μg·kg⁻¹·min⁻¹). In comparison, procainamide was administered as an infusion in 11 of 14 patients (79%) at a median dose of 20 μg·kg⁻¹·min⁻¹ (10 to 40 μg·kg⁻¹·min⁻¹, P=NS).

Other antiarrhythmic agents were administered before or during 14 of the amiodarone-treated episodes (54%): digoxin (n=12), propranolol (n=2), esmolol (n=2), flecainide (n=1), and lidocaine (n=1). In the procainamide group, 9 (64%) received other antiarrhythmic medications (P=NS compared with amiodarone): digoxin (n=4), esmolol (n=3), propranolol (n=2), and lidocaine (n=2).

Ten patients received both amiodarone and procainamide and comprised a subgroup of crossover subjects. Of these 10 patients, 8 initially received amiodarone followed by procainamide (amiodarone-to-procainamide), whereas the remaining 2 were started on procainamide and subsequently changed to amiodarone (procainamide-to-amiodarone).

Efficacy
The Figure illustrates the treatment responses for both medications; Table 3 shows the rates of full success, partial success, and failure responses to each medication when used as the first treatment option in the 40 episodes of SVT. If partial success is included with full success, procainamide was successful in 10 of 14 episodes (71%), whereas amiodarone was successful in only 9 of 26 episodes (34%, P=0.046). When partial success is instead counted as a failure, procainamide was successful in 7 of 14 (50%), compared with only 4 of 26 (15%) for amiodarone (P=0.029). The limited patient numbers for each SVT subtype do not allow adequate statistical comparisons, but a trend toward higher full success with procainamide was seen in the IART group (P=0.083).

Among the 8 amiodarone-to-procainamide crossover patients, 4 achieved full success, 1 achieved partial success, and the remaining 3 patients failed both therapies. Of the 2 procainamide-to-amiodarone crossover subjects, 1 failed both medications whereas the other achieved full success but had the only major AE in the study. In a secondary analysis including crossover treatments as independent episodes (40 primary events +10 crossovers=50 total events), procainamide achieved success in 15 of 22 episodes (68%) if full and partial success are combined compared with 10 of 28 episodes (36%) for amiodarone (P=0.023). Conversely, when partial success is combined with failures in this secondary analysis, procainamide was successful in 11 of 22 episodes (50%) and amiodarone was successful in 5 of 28 episodes (18%, P=0.016). Using this secondary analysis, no statistically significant differences were seen for the baseline characteristics of procainamide versus amiodarone recipients described in Table 1.

Adverse Events
AEs are described in Table 4 for all administrations of either medication and did not differ significantly for amiodarone versus procainamide. The 1 major AE occurred in a procainamide-to-amiodarone crossover patient who had profound bradycardia and hypotension after receiving a large amiodarone dose (10 mg/kg over 1 hour). There was 1 death in a patient receiving amiodarone, but this was attributed to sepsis and progressive deterioration from the patient’s primary cardiac disease.

Hypotension and bradycardia were the most common minor AEs among amiodarone recipients. Clinical and ECG events were more evenly distributed among procainamide patients. Among the crossover patients, both procainamide-to-amiodarone subjects had an AE, with 1 experiencing a major event (described above) and the other with bradycardia (minor). Of the 8 amiodarone-to-procainamide crossovers, 4 patients had a total of 8 complications after crossover to procainamide: bradycardia (n=2), first-degree AV block (n=2), QRS prolongation (n=2), hypotension (n=1), and ventricular bigeminy (n=1). There was therefore a 50% incidence (4 of 8 patients) of AEs in the amiodarone-to-procainamide patients, compared with only 14% (2 of 14 patients) in the patients only receiving procainamide (P=NS). If the potential influence of medication crossover is excluded, AEs occurred in 35% (9 of 26 patients) of those who only received amiodarone compared with only 14% (2 of

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**Table 1. Patient Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Procainamide (n=14)</th>
<th>Amiodarone (n=26)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (median, range)</td>
<td>353 d (0 d to 19 y)</td>
<td>18 d (0 d to 8 y)</td>
<td>0.04</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>7 (50%)</td>
<td>9 (35%)</td>
<td>0.34</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>6 (43%)</td>
<td>20 (77%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Postoperative arrhythmia</td>
<td>2 (14%)</td>
<td>18 (69%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Acquired heart disease</td>
<td>2* (14%)</td>
<td>1† (4%)</td>
<td>0.28</td>
</tr>
<tr>
<td>Other medical conditions</td>
<td>2‡ (14%)</td>
<td>0%</td>
<td>0.12</td>
</tr>
<tr>
<td>Isolated SVT</td>
<td>4 (29%)</td>
<td>5 (19%)</td>
<td>0.69</td>
</tr>
</tbody>
</table>

**SVT subtypes**
- **ORT**: 3§ (21%), 8 (31%) (P=0.72)
- **Wolff-Parkinson-White**: 1, 2
- **Concealed accessory pathway**: 2, 6
- **IART**: 4§ (29%), 14 (54%) (P=0.19)
- **EAT**: 7 (50%), 4 (15%) (P=0.03)
- **Multifocal**: 1, 1

*One patient with hypertrophic cardiomyopathy, 1 patient with tuberous sclerosis and rhabdomyomas.
†One patient with dilated cardiomyopathy.
‡One patient s/p lung transplant, 1 patient with polycystic kidney disease.
§One patient had ORT and IART on separate admissions.

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**Table 2. Comparison of Age and Presence of Congenital Heart Disease Between Patients With ORT/IART and EAT**

<table>
<thead>
<tr>
<th></th>
<th>ORT (n=11)</th>
<th>IART (n=18)</th>
<th>EAT (n=11)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age</td>
<td>28 d</td>
<td>14 d</td>
<td>131 d</td>
<td>0.088</td>
</tr>
<tr>
<td>Age range</td>
<td>1 d to 2 y</td>
<td>0 d to 19 y</td>
<td>1 d to 14 y</td>
<td></td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>8 (73%)</td>
<td>15 (83%)</td>
<td>3 (27%)</td>
<td>0.0073</td>
</tr>
</tbody>
</table>

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**Table 3. Comparison of Full Success, Partial Success, and Failure Responses to Each Medication**

<table>
<thead>
<tr>
<th></th>
<th>Procainamide</th>
<th>Amiodarone</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full success</td>
<td>10 of 14</td>
<td>5 of 26</td>
<td>0.046</td>
</tr>
<tr>
<td>Partial success</td>
<td>5 of 14</td>
<td>9 of 26</td>
<td>0.029</td>
</tr>
<tr>
<td>Failure</td>
<td>9 of 26</td>
<td>10 of 28</td>
<td></td>
</tr>
</tbody>
</table>
14 patients) of those who only received procainamide ($P=NS$).

**Neonates (<30 Days Old)**

There were 20 patients (54%) who were <30 days of age at the time of medication administration. Amiodarone was given as the initial therapy in 16 patients and procainamide was given to 4 (Table 5). In these neonates, congenital heart disease was present in 15, and 1 patient had tuberous sclerosis with associated cardiac rhabdomyomas. The remaining 4 patients had isolated SVT.

IART was the predominant arrhythmia in neonates (12 episodes, compared with 6 with ORT and 2 with EAT). The small patient numbers did not show statistically significant differences for efficacy of procainamide versus amiodarone. Among the neonates, 5 minor AEs occurred after the administration of amiodarone (hypotension in 2, bradycardia in 3), with no AEs after procainamide administration ($P=NS$).

**Patients With Congenital Heart Disease**

Of the 37 patients in the study cohort, 24 had congenital heart disease (65%). A total of 26 episodes of SVT were treated: Amiodarone was initially given in 20 and procainamide was given in 6 (Table 5). The small patient numbers did not show statistically significant differences for efficacy of procainamide versus amiodarone. Among the neonates, 5 minor AEs occurred after the administration of amiodarone (hypotension in 2, bradycardia in 3), with no AEs after procainamide administration ($P=NS$).

IART was the treated arrhythmia in 15 cases, ORT in 8 cases, and EAT in 3 cases. The only major AE occurred in a patient with congenital heart disease who was also a procainamide-to-amiodarone crossover. There were 10 additional minor AEs among the 20 cases treated with amiodarone (hypotension in 4, bradycardia in 5, QRS prolongation in 1), compared with 1 of 6 cases treated with procainamide (hypotension). These differences in AEs did not reach significant difference.

**Discussion**

SVT that is refractory to conventional treatment is a relatively uncommon problem in pediatric patients and more likely to be problematic in those with impaired ventricular function or in the immediate interval after surgery for congenital heart disease. Treatment is often empirical, based on individual experience and institutional preferences. This study compared the relative efficacy of procainamide versus amiodarone for the treatment of recurrent SVT in pediatric patients. Many of the patients in this cohort were very young, had complex structural heart disease, and were being treated in the acute postoperative setting after cardiac surgery, adding additional elements of complexity to arrhythmia management. Despite these factors and the limited patient numbers, significant benefit with the use of procainamide was demonstrated. At the same time, AEs did not differ significantly between the 2 medications.

These results may challenge common practice, as amiodarone is considered by many to be both effective and safe and is often selected as the primary agent for arrhythmia management due to a perceived lack of negative inotropic effects. Prior study has suggested that amiodarone may even improve ventricular function by increasing coronary blood flow and decreasing cardiac workload. In terms of efficacy, retrospec-

**Table 3. Comparison of Overall and Subtype Success Between Amiodarone and Procainamide**

<table>
<thead>
<tr>
<th></th>
<th>ORT</th>
<th>IART</th>
<th>EAT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amiodarone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full success</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4 (15%)</td>
</tr>
<tr>
<td>Partial success</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>5 (19%)</td>
</tr>
<tr>
<td>Failure</td>
<td>3</td>
<td>10</td>
<td>4</td>
<td>17 (66%)</td>
</tr>
<tr>
<td><strong>Procainamide</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full success</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7 (50%)</td>
</tr>
<tr>
<td>Partial success</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3 (21%)</td>
</tr>
<tr>
<td>Failure</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4 (29%)</td>
</tr>
<tr>
<td>Partial counted as success ($P$ value)</td>
<td></td>
<td></td>
<td></td>
<td>0.046</td>
</tr>
<tr>
<td>Partial counted as failure ($P$ value)</td>
<td></td>
<td></td>
<td></td>
<td>0.029</td>
</tr>
</tbody>
</table>

**Table 4. Adverse Events**

<table>
<thead>
<tr>
<th></th>
<th>Amiodarone ($n=28$)</th>
<th>Procainamide ($n=22$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with major AEs</td>
<td>1 (4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Patients with minor AEs</td>
<td>10 (36%)</td>
<td>6 (27%)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>AV block (any degree)</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ventricular ectopy</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>QRS prolongation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>QT prolongation</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

![](Figure.png)
Partial counted as failure (P value) 0.58 0.35
Partial counted as failure (P value) 0.55 0.11

Research on procainamide in pediatric patients has been largely limited to safety trials and retrospective studies. The use of procainamide in the management of adult ventricular arrhythmias and atrial fibrillation is well established, as well as the potential for adverse effects with class IA agents. However, safe dosing regimens have been reported in pediatric patients. Using an intravenous dosing regimen similar to that used for older children and adults to achieve therapeutic levels, Moffet et al demonstrated that neonatal recipients did not have hypotension, heart block, GI disturbances, rash, or lupus-like reactions. That study primarily focused on the pharmacodynamics and metabolism of procainamide in young infants and, while the medication was given to treat EAT, JET, and atrial flutter, the efficacy of treatment was not reported. Benson et al found that 11 of 12 pediatric subjects given periodic single dose oral procainamide had successful termination of paroxysmal SVT. However, these 12 patients comprised the only successful responders among 27 subjects previously given intravenous procainamide for inducible SVT during electrophysiological evaluation, suggesting only a 44% success rate for acute, short-term conversion with intravenous therapy.

Amiodarone and procainamide have been compared in the management of SVT in adults. Chapman et al showed equal efficacy between amiodarone and procainamide in the management of atrial tachyarrhythmias among critically ill adults (71% effective for amiodarone compared with 70% for procainamide with no significant differences in time to conversion or AEs). The appropriateness of extrapolating this data to pediatric patients, who have both varied arrhythmic substrates and presumably different medication effects, is unclear. Several pediatric studies have evaluated the individual efficacy of amiodarone and procainamide in the treatment of JET, but these studies have not compared the medications simultaneously, limiting conclusions regarding their comparative efficacy.

Because of the retrospective nature of this study, the definitions of success were somewhat arbitrary but based on prior studies in the literature. The multiple SVT mechanisms included as well as the variable clinical outcomes and dosing regimens further complicated these definitions. For the case of EAT, an overall heart rate slowing of at least 20% or an absolute heart rate <180 beats per minute were used to define success and were based on the criteria outlined by Saul et al.

Several patients did not fit under the strict definition of success but clearly exhibited clinical improvement after medication administration without need for further antiarrhythmic management. As a result, a partial success category was included, and the final statistical analyses were made with partial success included as either treatment success or failure. Nevertheless, with either analysis, advantages of procainamide over amiodarone were demonstrated.

Continuous infusion therapy was used more frequently with procainamide, and dosing was more uniform and consistent for procainamide compared with amiodarone. Initial bolus dosing was less standardized with amiodarone, with half of the patients receiving what has been considered low-to-medium dosed boluses at sporadic time intervals. In
contrast, procainamide followed a more uniform load-infusion regimen at well-accepted, standard doses.\textsuperscript{12,13} Duration of therapy varied considerably and was not directly related to initial response to treatment.

The frequency of AEs was not statistically different between the agents. With amiodarone, minor AEs were predominantly hypotension and bradycardia. These effects have been well described in multiple studies of amiodarone administration in children,\textsuperscript{5,6,10,15} which have reported a variable incidence of AEs and linearly correlated a higher risk of events with higher doses of medication. AEs among our procainamide recipients were evenly distributed across both clinical and ECG events. Ventricular proarrhythmia and hypotension are known potential side effects of procainamide administration.\textsuperscript{8,12,13} Furthermore, prolongation of both QRS duration and the QTc have been reported due to slowing of depolarization and repolarization with procainamide.\textsuperscript{15} In our study, no ventricular arrhythmias—related or unrelated to QTc prolongation—were observed in our procainamide recipients.

Crossover patients represent a unique subset given the potential for both improved efficacy and increased risk for AEs. Because of the small sample size among this study cohort, definitive conclusions regarding crossover patients were not possible. Although the results of the second medication administered cannot be considered an independent event, an ad hoc secondary analysis including these crossover events as separate events showed a similar advantage of procainamide over amiodarone. Other findings related to these crossovers are also noteworthy. All amiodarone-to-procainamide crossovers were patients with congenital heart disease. The majority (7 of 8 patients) had SVT in the postoperative period with 5 treated for postoperative IART. Of these 8 patients, 5 achieved either full or partial success and 4 developed minor AEs after conversion to procainamide. This suggests that procainamide can be successful in SVT cases that have failed amiodarone therapy. However, there was a trend toward more AEs in procainamide recipients who had previously received amiodarone compared with those who only received procainamide, with the minor events seen in amiodarone-to-procainamide crossovers accounting for the majority of events among all procainamide recipients. Less can be deduced from the 2 procainamide-to-amiodarone crossover patients regarding efficacy; however, both had AEs, including the only major event among the entire cohort. Although the data may infer a better safety profile for procainamide compared with amiodarone (despite this study being underpowered to prove this), these findings also emphasize the need for careful monitoring of patients who are administered one of these medications after the other has failed.

**Study Limitations**

This study was limited because of retrospective nature. Therefore, uniformity and availability of all desired study variables and end points could not be obtained. ECG data were not available at all time points, thereby possibly obscuring the true incidence of therapy-induced ECG changes. In EAT, atrial rate response could not be continuously assessed given that this was not documented at all time points. Success differed for IART, depending on the frequency of the arrhythmia before treatment and whether the medication was used for either chemical cardioversion or prevention of recurrence.

Retrospective analysis prevented the ability to compare uniform dosing regimens and administration of the medications. Amiodarone dosing tended to be less uniform, more sporadic, and more conservative regarding dosage, which could have affected its efficacy. However, larger scheduled doses of amiodarone may also have resulted in a higher incidence of AEs.

The influence of additional antiarrhythmics with amiodarone or procainamide could not be sufficiently studied given the retrospective design. Although there was no statistically significant difference between the study groups with regard to the general use of other antiarrhythmic agents, sample sizes and the variability of these alternative agents compromised a thorough evaluation of their impact.

Finally, the retrospective nature of this study may have introduced a significant selection bias. Procainamide was largely administered under the guidance of an electrophysiologist. This was not always the case with amiodarone, which was often initiated at the discretion of cardiac intensivists and managing cardiologists. This may have affected the accuracy of initial diagnoses, choice and dosage of medications, and use of other treatment modalities, which in combination, may have biased our comparison of success between procainamide and amiodarone.

**Conclusion**

The findings of this study suggest that procainamide is more effective than amiodarone in the acute treatment of recurrent pediatric SVT without statistically significant differences in overall AE profiles. Although the data alone may not be sufficient to recommend procainamide over amiodarone, it suggests a need to reconsider the perceived superiority and safety of amiodarone and consider an expanded role of procainamide in pediatric arrhythmia management. Additional prospective study should be pursued to further compare these agents in an effort to develop more specific, effective, and safer guidelines for the treatment of pediatric patients with recurrent SVT.

**Disclosures**

None.

**References**

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CLINICAL PERSPECTIVE
Relative efficacy of different pharmacological approaches to the management of recurrent supraventricular arrhythmias in pediatric patients is largely unknown because systematic comparisons between the various antiarrhythmic agents are limited, the number of patient cohorts available for study is small, and the end points for treatment are variable. This retrospective single-institution study included 37 patients (median age, 34 days; the majority with congenital heart disease) with recurrent supraventricular tachycardia. The majority had atrial arrhythmias and a quarter had reentry using an accessory pathway. Intravenous administration of procainamide was more effective than intravenous amiodarone, without substantial differences in the incidence of adverse events, a somewhat surprising finding given the general perception of amiodarone therapy. The findings suggest that intravenous procainamide warrants an important role in the management of pediatric patients with recurrent supraventricular arrhythmias.
Amiodarone Versus Procainamide for the Acute Treatment of Recurrent Supraventricular Tachycardia in Pediatric Patients
Philip M. Chang, Michael J. Silka, David Y. Moromisato and Yaniv Bar-Cohen

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