Amiodarone Therapy for Drug-Refractory Fetal Tachycardia

Janette F. Strasburger, MD; Bettina F. Cuneo, MD; Maaike M. Michon, MD; Nina L. Gotteiner, MD; Barbara J. Deal, MD; Scott N. McGregor, DO; Martijn A. Oudijk, MD; Erik J. Meijboom, MD; Leonard Feinkind, MD; Michael Hussey, MD; Barbara V. Parilla, MD

Background—Fetal tachycardia complicated by ventricular dysfunction and hydrops fetalis carries a significant risk of morbidity and mortality. Transplacental digoxin is effective therapy in a small percentage, but there is no consensus with regard to antiarrhythmic treatment if digoxin fails. This study evaluates the safety, efficacy, and outcome of amiodarone therapy for digoxin-refractory fetal tachycardia with heart failure.

Methods and Results—Fetuses with incessant tachycardia and either hydrops fetalis (n=24) or ventricular dysfunction (n=2) for whom digoxin monotherapy and secondary antiarrhythmic agents (n=13) were not effective were treated transplacentally with a loading dose of oral amiodarone for 2 to 7 days, followed by daily maintenance therapy for <1 to 15 weeks. Digoxin therapy was continued throughout gestation. Newborns were studied by transesophageal pacing or ECG monitoring to determine the mechanism of tachycardia. Three fetuses were delivered urgently in tachycardia during amiodarone loading, and 3 required additional antiarrhythmic agents for sustained cardioversion. Amiodarone or amiodarone combinations converted 14 of 15 (93%) with reentrant supraventricular tachycardia, 2 of 2 with ventricular or junctional ectopic tachycardia, and 3 of 9 (33%) with atrial flutter. Amiodarone-related adverse effects were transient in 5 infants and 8 mothers. Mean gestational age at delivery was 37 weeks, with 100% survival.

Conclusions—Orally administered amiodarone is safe and effective treatment for drug-refractory fetal tachycardia, specifically reentrant supraventricular tachycardia, junctional ectopic, or ventricular tachycardia, even when accompanied by hydrops fetalis or ventricular dysfunction. (Circulation. 2004;109:375-379.)

Key Words: tachycardia ■ atrial flutter ■ antiarrhythmia agents ■ fetus ■ amiodarone

Successful in utero cardioversion of sustained fetal tachycardia complicated by hydrops fetalis has improved to 60% to 85% with transplacental antiarrhythmic therapy, yet many centers with large series of patients have reported fetal and neonatal mortality as high as 8% to 30%. Potential contributing factors for high mortality include failure to achieve cardioversion with subsequent progression of hydrops fetalis, multiple interventional procedures, premature delivery, and possible proarrhythmia. Digoxin is the most common first-line antiarrhythmic agent for fetal tachycardia. If digoxin fails, there is no consensus on the most effective and safest secondary agent for tachycardia conversion. The present study reports our experience using amiodarone, a highly effective antiarrhythmic agent in children, for the treatment of drug-refractory tachycardia in the fetus with hydrops or myocardial dysfunction.

Methods

Between August 1990 and July 2002 at 5 Chicago-area hospitals (25 patients) and Utrecht, the Netherlands (1 patient), 26 fetuses (16 male, 10 female) under 36 weeks of gestation received amiodarone therapy using a uniform protocol for treatment of tachycardia. This represented all fetuses with hydrops for whom previous therapy had failed in 5 Chicago Hospitals in which, after 1991, amiodarone was used predominantly as second-line rather than third-line therapy; and in Utrecht (University Hospital), after publication of their sotalol experience in 2000, amiodarone was used for drug-refractory tachycardia. Some patients were referred to the Chicago hospitals after failure of second-line agents at other centers. No fetuses treated with amiodarone were excluded from this analysis. In all cases, both maternal and fetal records were reviewed. Twenty-four fetuses had hydrops fetalis, and 2 had ventricular dysfunction without hydrops. Ventricular dysfunction was identified when left or right ventricular shortening fraction measured <20% by echocardiogram, with atrioventricular (AV) valve regurgitation. Tachycardia was sustained for >12 hours without conversion or with only brief spontaneous conversions in all. Fetal tachycardia was defined as a fetal heart rate...
of mechanisms is listed in the section on neonatal ECG findings. Gestational ages at presentation did not differ with tachycardia mechanism.

Response to Therapy
Drug efficacy is outlined in Table 2 for the 26 fetuses. Treatments listed were amiodarone and digoxin; amiodarone alone; or amiodarone, digoxin, and a third agent. Mean time to conversion was 6 days (range, 2 to 21 days). Two patterns of conversion were observed during fetal tachycardia. The most common was a gradual decline in tachycardia rate before termination. In 2 fetuses, an abrupt and permanent conversion occurred within 3 days without significant rate decline. Mean cumulative amiodarone dose at load end (7 days) was 12.3 g (range, 8.4 to 16.8 g). The duration of in utero therapy ranged from 1 to 15 weeks (mean, 34 days). Amiodarone was discontinued for quiescent tachycardia (n=9) an average of 4 weeks before delivery. Recurrence of fetal tachycardia occurred in 1 patient 3 weeks after discontinuation. One fetus treated with amiodarone did not convert until digoxin was added to the regimen. Mean time to resolution of hydrops was 11 days (range, 2 to 56 days).

Indications for and Mode of Delivery
All fetuses and infants survived. Prematurity (<37 weeks gestation) was 31%. Mean gestation for those on maintenance

| TABLE 2. Response to Digoxin and Oral Amiodarone Therapy or Amiodarone Combinations |
|---------------------------------|--------|--------|--------|--------|
| **AVRT** | **AF** | **VT** | **JET** |
| Delivered during amio loading | 1/15   | 2/9    | 0/1    | 0/1    |
| Conversion: Amio + dig or amio alone | 11/15(73) | 3/9(33) | 1/1(100) | 1/1(100) |
| Conversion: Amio + dig + verapamil or flecainide | 3/15(20) | ... | ... | ... |
| Total converting with treatment | 14/15(93) | 3/9(33) | 1/1(100) | 1/1(100) |

Values are n/total n treated (% success). Amio indicates amiodarone; dig, digoxin. Other abbreviations as in Table 1.
amiodarone was 37 weeks (range, 30 to 41 weeks) and for those delivered prematurely, 35 weeks (range, 33 to 37.5 weeks). There were no differences in the gestational ages at delivery between fetuses with supraventricular tachycardia (SVT) or atrial flutter (39 versus 37 weeks, respectively, \( P=0.5 \)). The cesarean section rate in premature fetuses was 100%, and in the term group, 16%. Mean birth weight was 3.2 kg (range, 1.6 to 4.0 kg).

**Maternal and Fetal Adverse Side Effects**

Side effects related or potentially related to amiodarone are summarized in Table 3. Side effects serious enough to withdraw amiodarone were encountered in 1 mother with a photosensitivity dermatitis and thrombocytopenia (minimum platelet count, 55,000). One mother with normal thyroid function during the treatment period developed hypothyroidism 6 months postpartum requiring thyroid supplementation. In limited cases in which amiodarone serum levels were obtained, low or low-therapeutic values were noted. Thyroid functions derived from cord blood at delivery were normal in all except 5 infants. These 5 had a mean TSH of 26 IU, all except 5 infants. These 5 had a mean TSH of 26 IU, with low-normal T4 levels (differing assays). Repeat venipuncture values were normal at 2 weeks of age in 4 without treatment. The fifth infant was lost to follow-up. One infant treated with amiodarone in utero and postnatally, with normal thyroid function at birth, developed clinical hypothyroidism at 3 months. No fetuses were small for gestational age. During follow-up, no formal developmental testing was performed in the pediatric cardiology clinics; however, 2 of 26 infants had been evaluated for mild speech acquisition delays without hearing loss. TSH had not been elevated in these infants; however, 1 had required 21 days of treatment with amiodarone before conversion and had been on combination therapy and delivered in sinus rhythm at 30 weeks of gestation.

**Maternal and Neonatal ECG Findings**

Non-specific ST-T–wave abnormalities were common during digoxin therapy. Additional rhythm abnormalities and ECG changes associated with amiodarone are summarized in Table 3. Only intervals from neonates receiving amiodarone near the time of delivery and for whom preexcitation was not present are reported. Mild maternal bradycardia or PR prolongation responded to reduction in either digoxin doses or amiodarone doses, and QT prolongation responded to decreasing the amiodarone dose. All rhythm changes developed during loading. Amiodarone significantly decreased maternal heart rate and increased PR and QRS intervals (Table 3). Except as noted, these intervals remained within normal range. During maintenance therapy, fetal heart rate patterns remained reactive during nonstress testing, but fetal heart rates were slightly lower than expected for gestational age.

**Neonatal Electrophysiological Findings**

Mechanisms of tachycardia were because of accessory AV connections with manifest Wolff-Parkinson-White syndrome in 2, concealed accessory connections in 13, atrial flutter with concealed accessory AV connections in 2, atrial flutter alone in 7, junctional ectopic tachycardia in 1, and ventricular tachycardia with intermittent AV block and atrial flutter in 1. Two fetuses with atrial flutter in utero were noninducible at TEP and had no clinical tachycardia. Postnatal antiarrhythmic therapy was given to 19 of 26 infants on the basis of clinical recurrence (13 patients) or TEP findings (6 patients). In 11 of

---

**TABLE 3. Maternal and Neonatal ECG/Rhythm Characteristics and Side Effects With Digoxin and Oral Amiodarone or Amiodarone Combinations**

<table>
<thead>
<tr>
<th>ECGs</th>
<th>Heart rate, bpm</th>
<th>Pre</th>
<th>Load</th>
<th>Maintenance</th>
<th>Neonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR, ms</td>
<td>146±19</td>
<td>162±25*</td>
<td>168±15*</td>
<td>127±28</td>
<td></td>
</tr>
<tr>
<td>QRS, ms</td>
<td>81±6</td>
<td>88±10*</td>
<td>93±11*</td>
<td>65±13</td>
<td></td>
</tr>
<tr>
<td>QTc, ms</td>
<td>419±19</td>
<td>429±27</td>
<td>436±31</td>
<td>412±28</td>
<td></td>
</tr>
<tr>
<td>WPW</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>RAE/BAE</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>ST depression</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Rhythm findings

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Maternal</th>
<th>Neonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus bradycardia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>First-degree AVB</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Mobitz I second-degree AVB</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>QTC prolongation &gt;500 ms</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Skin rash/thrombocytopenia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thyroid dysfunction</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

AVB indicates atrioventricular block; Load, amiodarone loading phase; Maintenance, amiodarone maintenance phase; ms, milliseconds; Pre, before amiodarone initiation; RAE/BAE, right or biatrial enlargement; and WPW, Wolff-Parkinson-White before excitation.

*\( P<0.05 \) vs pretreatment ECG.
19, the regimen ultimately included initiation of amiodarone.

**Discussion**

In this study, 14 of 15 fetuses in heart failure secondary to SVT and 2 of 2 with ventricular or junctional tachycardia converted to sustained sinus rhythm when treated with amiodarone or combination regimens including amiodarone. All 26 fetuses were delivered alive, with no serious sequelae of prematurity. Side effects of amiodarone were transient and precluded continued administration in only 1 of 26 mothers. These results support the use of amiodarone for the hydropic fetus with reentrant SVT refractory to transplacental and direct intramuscular digoxin. Amiodarone successfully treated fetal SVT even when multiple other antiarrhythmic agents had failed.

**Amiodarone Efficacy and Safety**

Although direct comparison with other studies conducted at different institutions and over differing time periods is not possible, some review of published experience with fetal tachycardia management is warranted. Several agents have been suggested as first- or second-line therapy for fetal tachycardia with hydrops, but no agent has been shown to be consistently effective and safe. Few agents have been used in combinations other than with digoxin. Two antiarrhythmic agents currently thought to be highly successful in fetal cardioversion have significant associated mortality rates under certain circumstances. Sotalol, a class III agent with β-blocker activity, converted 40% to 60% of hydropic fetuses with SVT, but with a 25% to 30% mortality. Similarly, flecainide has a 60% to 85% efficacy but up to 18.5% mortality for refractory fetal tachycardia associated with hydrops. Jouannic et al reported sudden death in 1 fetus with mild ascites and normal ventricular function within 12 hours of initiation of flecainide and another with hemo-

dynamic deterioration necessitating delivery. Oudijk et al also reported similar sudden demise shortly after initiation or dose increase for sotalol. These experiences directly contrast with the present study, in which all hydropic fetuses survived. Although ECG effects were noted postnatally, profound bradyarrhythmias necessitating emergent delivery or severe conduction defects, such as reported with flecainide, were not noted.

Amiodarone has been shown in many pediatric studies and in anecdotal accounts in the fetus to be highly efficacious when other drugs have failed. Crossover efficacy for amiodarone for reentrant SVT was seen in this series and has been reported in other fetal studies for both flecainide and sotalol response failures. Some investigators have advocated partial SVT control when slowing of the rate results in a triphasic venous flow pattern. However, in this series, progression of hydrops fetalis in the setting of partial control necessitated alternative effective drug therapy with amiodarone.

**Other Management Strategies**

**Enhancing Conversion**

In addition to the selection of amiodarone treatment, other factors may have contributed to fetal survival. An intramuscular rather than intracordal route of direct fetal digoxin administration was used. The authors have reported more rapid conversion of SVT with intramuscular digoxin administration than with maternal administration alone in the hydropic fetus. Cardiac arrest and negative inotropic effects with intracordal administration of drugs have been reported previously, including with amiodarone, as has death caused by cord injury. Finally, a third agent in addition to amiodarone and digoxin was used for cardioversion in 3 patients with SVT rather than accepting partial control or very premature delivery.

**Pharmacodynamics**

The transplacental transfer characteristics of amiodarone in the fetus have been controversial. Limited transplacental transfer has been reported. The antiarrhythmic action of amiodarone and its active metabolites is complex and does not lend itself to easy analysis because of its delayed accumulation and tissue deposition. This study suggests that amiodarone does not cause significant maternal or fetal hypotension from maternal intravenous amiodarone administration. Approximately 1 week after maternal amiodarone administration, an acute risk to the fetus was reduced compared with direct intracordal administration. Similarly, risk of maternal and fetal hypotension from maternal intravenous amiodarone administration was also avoided. Time to conversion with oral amiodarone was similar in this study to that reported for sotalol and flecainide.

**Side Effects**

Prolonged fetal exposure to amiodarone has been reported to cause biochemical and rare clinical hypothyroidism and possible fetal growth retardation. Because it was used for <15 weeks, the maternal and fetal exposure to amiodarone was shorter than with previous reports. Transient biochemical hypothyroidism was detected in 5 infants, but only 1, who received chronic postnatal amiodarone therapy, required treatment. One mother developed hypothyroidism 6 months postpartum; however, it is unlikely that this was caused by amiodarone treatment.

It is difficult to compare ECG results in this study with results from previous series of antiarrhythmic therapy, because detailed maternal and neonatal ECG findings associated with in utero tachycardia treatment in larger series of patients have not been published. Some mild increase in conduction intervals and reduction in rate were noted with amiodarone. In anecdotal accounts and in our experience, rare instances of right bundle-branch block (maternal, neonatal, or both) and marked QT prolongation have been observed with flecainide (Reference 17 and Cuneo, personal communication). These marked ECG changes were not observed in this series. In a review of amiodarone treatment during pregnancy, Widerhorn et al reported sinus bradycardia in 3% of neonates and prolonged QT interval in 9%, but these fetuses had been exposed throughout pregnancy.

**Efficacy of Amiodarone for Atrial Flutter**

Although safe and efficacious for the treatment of SVT and ventricular and junctional tachycardia, amiodarone was
poorly effective in terminating atrial flutter. Oudijk et al have demonstrated 80% conversion with sotalol, or sotalol and digoxin, with no mortality in the atrial flutter group. Flack et al reported conversion of atrial flutter using amiodarone given by triple-route administration (intracardial, intraperitoneal, and transplacental) in 1 fetus with sotalol-refractory atrial flutter; however, transplacental administration alone did not seem sufficient.

**Limitations of the Study**

Limitations of this study include its long duration, necessitating retrospective chart analysis, and the involvement of multiple institutions. Because of the rarity of drug-refractory fetal tachycardia with hydrops fetalis, no single institution is likely to accumulate large numbers of patients. Direct comparisons with other studies are of limited value when they represent care over different time periods.

In summary, fetal tachycardia complicated by hydrops or ventricular dysfunction can be treated safely and effectively in utero even in drug-refractory cases. Assessment of the mechanism of fetal tachycardia, perhaps facilitated by the newer techniques of magnetocardiography and tissue velocity imaging, may help in choice of medication. Amiodarone seems to have low associated fetal mortality and excellent efficacy for treatment of SVT, junctional tachycardia, and ventricular tachycardia in the hydropic fetus. Its administration should be monitored by a team of clinical specialists with experience in arrhythmia management and familiarity with the side effect profile of amiodarone.

**Acknowledgments**

We thank the many pediatric and adult cardiologists, high-risk obstetricians, ultrasonographers, and neonatologists involved in the management of these patients and Sally McNally for manuscript preparation.

**References**


Amiodarone Therapy for Drug-Refractory Fetal Tachycardia
Janette F. Strasburger, Bettina F. Cuneo, Maaike M. Michon, Nina L. Gotteiner, Barbara J. Deal, Scott N. McGregor, Martijn A. Oudijk, Erik J. Meijboom, Leonard Feinkind, Michael Hussey and Barbara V. Parilla

Circulation. 2004;109:375-379; originally published online January 19, 2004;
doi: 10.1161/01.CIR.0000109494.05317.58
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2004 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://circ.ahajournals.org/content/109/3/375

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published
in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial
Office. Once the online version of the published article for which permission is being requested is located,
click Request Permissions in the middle column of the Web page under Services. Further information about
this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/