**Effect of Verapamil in Infants with Paroxysmal Supraventricular Tachycardia**


**SUMMARY** Twenty-nine consecutive spontaneous attacks of paroxysmal supraventricular tachycardia (PSVT) in 14 infants (mean age 4.4 months) were treated with verapamil. No infant had associated heart disease. Verapamil 1-2 mg i.v. was administered over 30 seconds. The dosage varied according to the weight of the infant. Within 60 seconds sinus rhythm was obtained in 28 instances (96.5%). No significant complications were observed. The high effectiveness, rapid action and lack of undesirable side effects observed in this series suggest that verapamil is the drug of choice in the treatment of PSVT in infants without underlying heart disease.

VERAPAMIL is considered by many authors to be the drug of choice in the treatment of paroxysmal supraventricular tachycardia (PSVT) in adults. It has been particularly effective in reciprocating junctional tachycardias with or without an associated extranodal pathway. The rapid action of verapamil and its quick elimination contribute to its clinical usefulness. This antiarrhythmic drug must be used with caution in patients with acute myocardial infarction, sick sinus syndrome and obstructive bronchopulmonary disease. Verapamil is contraindicated in patients with high-degree atioventricular (AV) block and in patients receiving beta-blocking agents; it is probably contraindicated as well in patients with severe primary heart failure.

Digitalis is considered the drug of choice in the treatment of PSVT in infants. However, as Lubbers et al. have stated, “the value of newer antiarrhythmic drugs remains to be fully evaluated” in this age group. Bein et al. reported excellent results with verapamil in the treatment of PSVT in infants and children. The present paper reports our results with verapamil in the treatment of PSVT in infants.

**Materials and Methods**

We treated 29 consecutive, spontaneous attacks of PSVT in 14 infants ages 5 days to 18 months (mean age 4.4 months) with verapamil. All attacks corresponded to supraventricular tachycardia (regular tachycardia with narrow QRS in a 12-lead ECG) of the paroxysmal type. Heart rate ranged from 214–330 beats/min. In seven infants (13 attacks) the ECG between attacks showed a Wolff-Parkinson-White syndrome, and in two other infants (three attacks) atrial echoes were observed after termination of tachycardia. Underlying heart disease could not be demonstrated in any infant by noninvasive methods. Only two infants had an acute intercurrent illness (pneumonia).

Before the administration of verapamil, we attempted to terminate tachycardia in all cases with vagal maneuvers or with a precordial blow. Attacks had begun 15 minutes to 2 days (possibly 5 days in one case) before verapamil was administered. In 18 attacks congestive heart failure was present; in five of them it was severe (pulmonary edema and/or physical signs of shock). In two patients 0.03 mg/kg digoxin i.v. had been administered 3 hours and 5 hours previously. Another patient had received procaainamide 1 hour before receiving verapamil.

Verapamil was given intravenously over 30 seconds, at a dosage of 1 mg in infants weighing < 5 kg, 1.5 mg in infants weighing 5–10 kg, and 2 mg in infants weighing > 10 kg. The dosage schedule was derived from that used in adults, according to the equivalent table of Talbot et al. This dosage schedule was successful in our first series of treated infants. In one case we administered an additional 0.5 mg because the usual dose failed (1 mg in an infant weighing 4.5 kg); in another case a higher dose (2 mg in a 5.6 kg infant) was required for the same reason; and in a third infant, a dose three times greater than scheduled (4.5 mg in a 5.8 kg infant) was inadvertently administered. In all cases administration of verapamil was carried out under continuous electrocardiographic monitoring.

**Results**

Stable sinus rhythm was obtained in 28 of 29 treated attacks. The only failure occurred in an infant in whom a higher-than-usual dose (2 mg in a 5.6 kg infant) did not abolish the tachycardia. This attack was terminated with a precordial blow, the same maneuver that was repeatedly ineffective before administration of verapamil. All attacks ceased immediately or within 60 seconds after administration of the drug. The heart rate usually slowed before the tachycardia stopped. In four instances there were atrial echoes or
short, self-limited runs of paroxysmal tachycardia. We observed transient depression of sinus automaticity (fig. 1) requiring no treatment in the only infant who had received procainamide 1 hour before. When present, heart failure disappeared a few hours after termination of tachycardia.

The only complication (severe hypotension with shock) was seen in the infant who inadvertently received a dose three times greater than recommended. This complication was successfully treated with isoproterenol.

Discussion

PSVT in infants is often a cardiac emergency. In this age group, correct diagnosis is often delayed because the initial symptoms (pallor, feeding troubles, vomiting) are vague. The degree of heart failure depends on the duration of the attack, on the heart rate and on any associated cardiac anomaly. Although prognosis is usually good, isolated fatal cases have been reported. In some series mortality is 2–11%, and death is related to heart failure or to complications of therapy.

Digitalis, considered to be the first-choice drug in the treatment of PSVT in infants, abolishes more than 90% of attacks. However, sinus rhythm is obtained within 10 hours. This delay is distressingly long in patients who do not tolerate PSVT, which may require the administration of other antiarrhythmic drugs, with unpredictable combined effects.

Verapamil involves neither blockade of the $\beta$-adrenoreceptors of the heart nor quinidine-like activity. Vaughan Williams considers verapamil to be a new, fourth type of antiarrhythmic drug. Specifically, verapamil blocks the slow calcium inward channel, but does not significantly modify the transmembrane sodium influx through the fast inward channel. The sinus node and the AV node are particularly sensitive to verapamil because normal impulse formation in the sinus node and conduction in the AV node appear to be maintained by slow channel-dependent mechanisms. The effect exerted by verapamil on AV conduction may explain its effectiveness in treating tachyarrhythmias.

Our results with verapamil are dramatic: Within 60 seconds sinus rhythm was obtained in 28 of 29 instances (96.5%). The only refractory attack was observed in a patient in whom verapamil had been successful in two previous episodes of tachycardia during his first admission. Interestingly, this refractory tachycardia was abolished with a precordial blow shortly after administration of verapamil. As this maneuver had been unsuccessful before verapamil we assume the the drug had some influence in the interruption of the tachycardia. Our results are similar to those reported by Bein et al., who obtained sinus rhythm in all the 70 attacks of PSVT in patients aged 4 days to 14 years.

Since some PSVTs are short-lived, the purist may argue that the termination of tachycardia is not always related to verapamil, but may be a spontaneous event. However, the very short interval between administration of the drug and termination of the tachycardia observed in this and other series strongly suggests that termination of tachycardia is due to the action of verapamil.

The following points should be emphasized:

Quick Action of Verapamil

All attacks but one ceased immediately after the administration of verapamil or within 60 seconds. We stress that after 3–5 minutes of its administration, verapamil cannot be assumed to have stopped the tachycardia. In case of failure of the drug, another therapeutic approach can be safely undertaken after this interval.
Stable Sinus Rhythm

The arrhythmia relapsed within 24 hours after its termination in only two infants. This frequency is similar to that reported with digitalis.16-18, 20

Verapamil and Heart Failure

In spite of the negative inotropic effect of verapamil,12, 13, 35 the signs of heart failure quickly subsided after termination of tachycardia. In our series heart failure was secondary to PSVT, and no infant had underlying heart disease. In the series of Bein et al.,22 two infants with severe congenital heart disease developed PSVT during heart catheterization; in both cases verapamil administration was followed by complete AV block with spontaneous return to sinus rhythm. Apitz et al.36 reported a fatal case after administration of verapamil in a 9-year-old child with primary cardiomyopathy and chronic heart failure. Singh et al.30 studied the effects of verapamil on hemodynamics in patients with heart failure and conclude that “the intrinsic negative inotropic action of verapamil is minimized by its effects on afterload so that cardiac index is not reduced by the drug in patients with cardiac disease.” However, in their series no patient was in functional class IV and all had basal left ventricular end-diastolic pressure < 20 mm Hg and ejection fraction > 40%. These authors were probably aware that their patients represented a selected heart disease population because at the end of the paper, in spite of the above-mentioned conclusions, they state: “caution should nevertheless be exercised in the use of verapamil in patients with severe myocardial decompensation.” All these data, along with the experimental studies of Nayler et al.,13 and our own experience in the adult4 suggest that verapamil is probably contraindicated in patients with severe heart failure secondary to or coincident with severe heart disease.

Absence of Complications

The important bradycardia and shock observed in one case must be related to the overdose administered by mistake. The effects of a dose three times greater than standard, however, were readily controlled by administration of isoproterenol, as has been reported in adults.4

Dosage

Two infants needed an additional dose (50% higher than standard) to interrupt the tachycardia. This suggests that it may be necessary to administer the higher dose in patients whose weight is on the upper limit of the range.

Summary

The results of this study suggest that verapamil is at least as effective as digitalis is reported to be16-21 in the treatment of PSVT in infants. In our series verapamil interrupted all instances of PSVT: directly in 28 cases and indirectly in one. Contrary to what has been reported in comparable series,16-18, 20 administration of antiarrhythmic drugs or cardioversion were not needed. It is possible to use other drugs (personal experience in adults, unpublished data) or electrical cardioversion2 shortly after administration of verapamil if this drug has been unsuccessful. Previous administration of digitalis does not contraindicate the use of verapamil, but concurrent use of β-blocking agents does.4 The high effectiveness, rapid action and lack of undesirable side effects observed in our series suggest that verapamil is the drug of choice in the treatment of PSVT in infants without underlying heart disease.

References

The Cardiac Conduction System in Situs Ambiguus

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SUMMARY The cardiac specialized conduction tissue was studied by serial sectioning in 13 cases of situs ambiguus. In four cases of right isomerism, we found paired sinus nodes in relation to a crista terminalis, and in each case a sling of conduction tissue between two atrioventricular nodes was present regardless of the ventricular morphology or cardiac position. In the cases with left isomerism, the sinus node was hypoplastic and abnormally located. We saw two types of atrioventricular conduction systems. In the three cases in which the morphologically right ventricle lay to the right of the morphologically left ventricle (presumed d-loop), a single atrioventricular bundle arose from a normally located atrioventricular node. In the five cases in which the morphologically right ventricle lay to the left of the morphologically left ventricle (presumed l-loop) and in the one case with a univentricular heart, paired atrioventricular nodes were present, linked or potentially linked by a sling of conduction tissue.

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visceral configuration with duplication of either left- or right-sided structures termed situs ambiguus. This frequently results in major malformations in the cardiovascular system. In situs ambiguus with right isomerism, duplication of right-sided structures, such as the crista terminalis, is associated with duplication of the sinus node. In the left isomorphic form, where the crista terminalis is absent, atrial depolarization is known to be abnormal as judged from the surface ECG. The sinus node has been reported to be abnormally located in two cases studied by Bharati and Lev, one with multiple spleens and the other with a single bilobed spleen.

The atrioventricular conduction system has not been studied extensively in hearts with situs ambiguus. We have previously observed a sling of ventricular conduction tissue connecting paired atrioventricular

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