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ORIGINAL ARTICLE

The epidemiology of arrhythmia in infants: A population-based study

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Aim: Cardiac arrhythmias are an important cause of morbidity in infants. Although the spectrum of types of arrhythmia has been reported, there has been no previous population-based study of the incidence of arrhythmias in infancy. Our aim was to define the population incidence of arrhythmia in infants.

Methods: We based this study on the Northern Region of England with a resident population of 3.1 million and an annual live birth rate of 33 000. We identified all clinically significant arrhythmias in infants in 1991–2010 from the regional cardiac database. All diagnoses were based on analysis of the electrocardiogram. Infants with only the substrate for arrhythmia (such as QT prolongation or ventricular pre-excitation) were excluded.

Results: In 20 years, there were 662 698 live births. We identified 162 cases of newly diagnosed arrhythmia of which 22 had associated structural cardiovascular malformations. The incidence of arrhythmia was 24.4 per 100 000 live births. The most common arrhythmia was atrioventricular re-entry tachycardia with an incidence of 16.3 per 100 000. Complete atrioventricular block and atrial flutter both occurred at 2.1 cases per 100 000 live births, and other arrhythmias were rare.

Conclusions: This study is the first to report a population incidence of arrhythmia in infants.

Key words: arrhythmia, cardiac; epidemiology; infant; paediatric.

What is already known on this topic

1 Classification, mechanism and outcomes of arrhythmias in infants are well documented.
2 However, the population incidence of arrhythmias in infants is not known, with estimates being based on studies that did not use a denominator population.

What this paper adds

1 Clinically significant sustained arrhythmias occur in 24 per 100 000 live births (1:4000), of which two-thirds is atrioventricular re-entry tachycardia.
2 Complete atrioventricular block and atrial flutter each occur in two per 100 000 live births. Other arrhythmias are rare.

Cardiac arrhythmias are an important cause of infant morbidity and an occasional cause of infant mortality. Most occur in infants with normal hearts, and the majority present to a neonatologist or a paediatrician before referral to a paediatric cardiologist. There are many reports of the prevalence at live birth of cardiovascular malformations (around 6–10 per 1000 live births).[1] There are also several reports documenting the classification and outcome of arrhythmias in the infant population, but there are no population-based reports of the incidence or prevalence of arrhythmias in infancy. This study was performed to define the incidence of clinically significant arrhythmias in live born infants.

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Methods

Patients

Our study was based on the former Northern Health Region of England with a population of 3.1 million and a recent annual live birth rate of around 33 000. We searched the regional cardiac database within the Northern Congenital Abnormality Survey (NorCAS) for records of all infants who were diagnosed with a sustained arrhythmia and who presented at less than year of age between 1 January 1991 and 31 December 2010. All diagnoses were reviewed and assessed by the authors based on analysis of the electrocardiogram (ECG) in tachycardia and in sinus rhythm and the response to interventions such as adenosine administration.

We classified arrhythmias using conventional diagnostic criteria[2] as one of the following: atrioventricular (AV) re-entry tachycardia, Wolff–Parkinson–White (WPW) syndrome, atrial flutter, atrial tachycardia, permanent junctional re-entrant tachycardia, congenital junctional ectopic tachycardia, multifocal atrial tachycardia, benign neonatal ventricular tachycardia,

Table 1 Incidence of arrhythmia in infants

Diagnosis	Number	Incidence per 100 000 live births (95% confidence interval)	Median age of presentation (days)
Total AVRT	108	16.3 (13.5–19.7)	18
AVRT with concealed pathway†	85	12.8 (10.4–15.9)	18
AVRT with WPW	23	3.5 (2.3–5.2)	18
Complete AV Block‡	14	2.1 (1.3–3.5)	1
Atrial flutter	14	2.1 (1.3–3.5)	2
Atrial tachycardia	7	1.1 (0.5–2.2)	8
PJRT	7	1.1 (0.5–2.2)	4
VT§	5	0.8 (0.3–1.8)	42
MAT¶	5	0.8 (0.3–1.8)	0
Congenital JET	2	0.3 (0–1.1)	77
Total	162	24.4 (21.0–28.5)	13

†Includes two who presented in atrial flutter. ‡Excludes one termination of pregnancy for complete AV block. §Excludes one fetus that did not survive to term. ¶Includes one infant who presented in atrial flutter. AV, atrioventricular; AVRT, atrioventricular re-entry tachycardia; JET, junctional ectopic tachycardia; MAT, multifocal atrial tachycardia; PJRT, permanent junctional reentrant tachycardia; VT, ventricular tachycardia; WPW, Wolff–Parkinson–White syndrome.

incessant idiopathic infant ventricular tachycardia or complete AV block. We included cases that presented in fetal life and had a post-natal recurrence.

Exclusions

We excluded the following from the study: postoperative AV block, postoperative junctional ectopic tachycardia; ventricular pre-excitation on the ECG without arrhythmia; long QT syndrome without arrhythmia; ventricular premature beats; atrial premature beats; and other non-sustained arrhythmias on ECG monitoring. We also excluded fetal cases with no post-natal recurrence or treatment and those with post-natal drug treatment but no arrhythmia (because the mechanism of arrhythmia could not be confirmed).

Statistical analysis

We limited statistical analysis to calculation of proportions and their associated confidence intervals (CIs).

Ethical approval

NorCAS is one of the seven linked surveys of maternal and infant health housed at the Regional Maternity Survey Office in Newcastle upon Tyne. The Patient Information Advisory Group has granted exemption from a requirement for consent for inclusion on the NorCAS register under section 60 of the Health and Social Care Act (2001). NorCAS, as part of the British Isles Network of Congenital Anomaly Registers, has ethical approval (04/MRE04/25) to undertake studies involving the use of the data.

Results

In 20 years, there were 662 698 live births, and 162 infants were diagnosed with a clinically significant arrhythmia (24.4 per 100 000 live births). There were also two terminations of pregnancy for fetal arrhythmia (one for complete heart block and one for ventricular tachycardia). Table 1 shows the incidence of each arrhythmia. Figure 1 demonstrates the age at presentation by arrhythmia diagnosis.

Atrioventricular re-entry tachycardia

The commonest arrhythmia was AV re-entry tachycardia with 108 cases, of which 21% had ventricular pre-excitation on the ECG in sinus rhythm. Included in this group were two neonates who presented with atrial flutter but developed AV re-entry tachycardia after cardioversion to sinus rhythm. The population incidence of all AV re-entry tachycardia was 16 per 100 000 live births and of WPW syndrome was 3.5 per 100 000 live births. The mean age at presentation was 33 days (range 0–310 days). One neonate in this group, with typical AV re-entry tachycardia that resolved in the first year of life, re-presented with tachycardia at the age of 5 years and a subsequent electrophysiology study documented AV nodal re-entry tachycardia.

Complete AV block

Fourteen infants had complete AV block. Twelve presented within the first 5 days and the other two at 18 days and 41 days of age. Six of the 14 (43%) complete AV block was associated with a structural cardiovascular malformation: three had a ventricular septal defect, one had a complete AV septal defect, one had a patent ductus arteriosus and atretic coronary artery ostium, and one had an atrial septal defect and mitral regurgitation. There was also one termination of pregnancy for complete AV block associated with non-immune hydrops (not included in the total).

Atrial flutter

Atrial flutter was seen as the only arrhythmia in 14 infants. Two others, who presented with atrial flutter, were not included in this group as they developed AV re-entry tachycardia after cardioversion to sinus rhythm. There were five patients with atrial flutter who had co-existing structural heart disease.

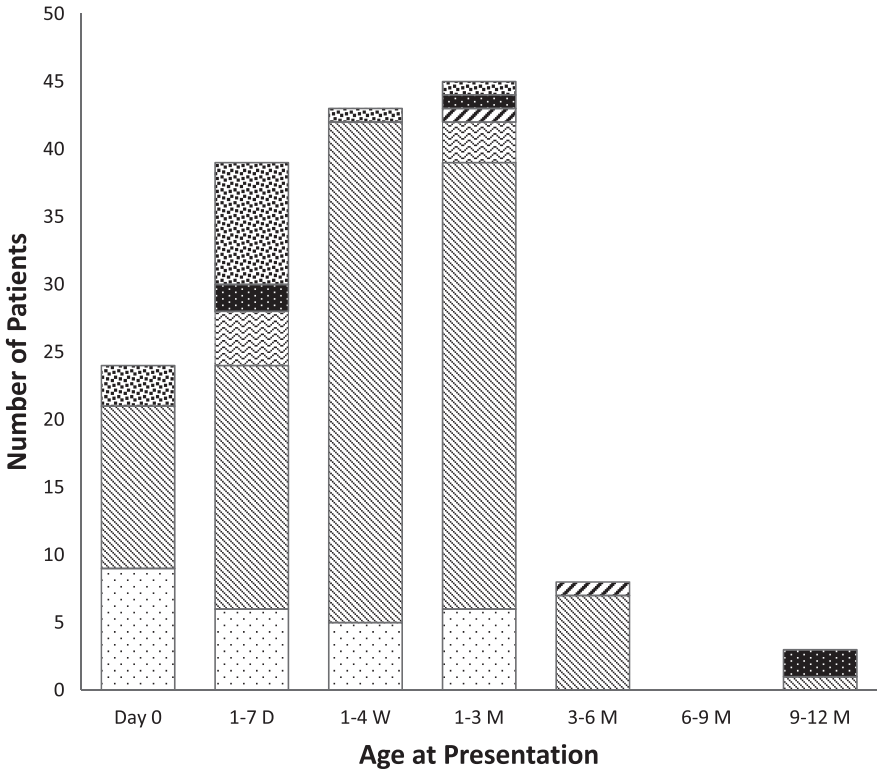

Fig. 1 Age of presentation by diagnosis. ⊠, complete AV block; ■, VT; ◪, congenital JET; ▨, PJRT; ▧, AVRT; □, atrial flutter, atrial tachycardia and MAT.

Atrial tachycardia

Of seven infants who presented with sustained atrial tachycardia, two had an associated cardiovascular malformation. Both had a muscular ventricular septal defect, and one also had mild Ebstein's anomaly of the tricuspid valve.

Permanent junctional reciprocating tachycardia

There were seven infants with permanent junctional reciprocating tachycardia. One infant with pre-excitation on ECG was initially diagnosed with AV re-entry tachycardia at 5 weeks of age. However, at electrophysiology study at 5 years of age, the diagnosis was typical permanent junctional reciprocating tachycardia with a bystander left free wall accessory pathway. None had associated congenital heart disease.

Ventricular tachycardia

Five infants had ventricular tachycardia. Three had benign neonatal ventricular tachycardia, two presenting at 3 days of age each and one presenting at 42 days. The other two had incessant idiopathic infant ventricular tachycardia, each presenting at 300 and 350 days of age. There was also one termination of pregnancy for ventricular tachycardia (not included in the total).

Multifocal atrial tachycardia

Five infants presented with multifocal atrial tachycardia. In one, the initial appearance was similar to atrial flutter, but after attempted direct current cardioversion, the ECG showed more typical multifocal atrial tachycardia.

Junctional ectopic tachycardia

Two infants presented with congenital junctional ectopic tachycardia.

Discussion

This is the first report to document the population incidence of clinically significant arrhythmias in infancy. We found a total incidence of 24 per 100 000 live births (95% CI 21–29) or 1:4000 (1:3500–1:4800), an incidence similar to that of individual structural malformations such as coarctation of the aorta or transposition of the great arteries.[1] AV re-entry tachycardia was by far the most common arrhythmia with an incidence of 16 per 100 000 live births.

There are few previous reports available for comparison and none that we are aware of with a denominator population. Massin *et al*. reported 250 children with tachycardia, of whom 109 (44%) were infants.[3] Infants made up 49% of those with supraventricular tachycardia and 15% of those with ventricular tachycardia. Ko *et al*. reported the changing spectrum of supraventricular tachycardia mechanisms in childhood in a single centre experience.[4] AV re-entry tachycardia was the diagnosis in 82% of infants with 14% being primary atrial tachycardia. Gilljam *et al*. reported experience of accessory pathway-mediated neonatal supraventricular tachycardia, also from a single centre.[5] They found that 34% (95% CI 26–43%) had evidence of ventricular pre-excitation, possibly slightly higher than our 21% (15–30%). Gilljam *et al*. documented a higher rate of resolution in the first year in those without

ventricular pre-excitation. None of these reports included a population denominator.

AV nodal re-entry tachycardia is probably very rare in infancy. We encountered one neonate with an ECG diagnosis of typical AV re-entry tachycardia, which resolved in infancy. He presented 5 years later with tachycardia, which was shown to be AV nodal re-entry tachycardia at a subsequent electrophysiology study. It is not possible to say whether the tachycardia mechanisms in early infancy and later childhood were the same or different. Massin *et al*. reported that 2 of 41 cases of AV nodal re-entry tachycardia were infants, but no details are given of how the diagnoses were made.[3] Crosson *et al*. reported that in 6 of 25 infants with supraventricular tachycardia who underwent oesophageal electrophysiology study, AV nodal re-entry tachycardia was the most likely diagnosis.[6] The diagnosis was based on a ventriculo-atrial (VA) interval of <70 ms on the oesophageal electrogram in five and on intracardiac recordings in one. The diagnostic criteria appear not to exclude the possibility of AV re-entry tachycardia with a concealed left posterior accessory pathway, which is much more common at this age. There was no late recurrence, and no description of the ECG features is given.

Gross *et al*. reported AV nodal re-entry tachycardia in 15 infants undergoing oesophageal electrophysiology study or post-operative epicardial atrial wire study.[7] Only 8 of 15 were symptomatic and the diagnosis was mainly based on a VA time of ≤70 ms. Some of the cases described obviously have some form of junctional rhythm, but diagnoses other than AV nodal re-entry tachycardia cannot be excluded. There is no description of the surface ECG appearances. Ko *et al*. reported that 3 of 18 patients with AV nodal re-entry tachycardia had first symptoms in infancy. Diagnosis was based on VA intervals at transoesophageal electrophysiology study later in childhood. The clinical and ECG characteristics were not described.[4]

The incidence of complete AV block in this study was 2.1 (95% CI 1.3–3.5) per 100 000 live births or 1:48 000 (95% CI 1:29 000–1:77 000). The prevalence at live birth of 'congenital' complete AV block is often quoted as 1:20 000 live births and referenced to Michaelsson's multicentre European report that was based on a voluntary registry.[8] In fact, that report does not contain a denominator population but merely refers to an earlier 1964 study.

The population prevalence of anti-SSA/SSB antibodies in female blood donors is around 4:1000 (95% CI 3–7),[9] and the risk of AV block in the offspring of mothers who are antibody positive is probably around 2% (95% CI 0.6–7%).[10] These figures are thus consistent with our finding of one case per 48 000.

All 14 cases in this study presented in the first 41 days of life. Villain *et al*. showed that 81% of cases with fetal or neonatal presentation are related to maternal anti-SSA/SSB antibodies and 86% of those diagnosed in the first year present in the first 28 days.[11]

Although each of the incessant tachycardias (congenital junctional ectopic tachycardia, permanent junctional reciprocating tachycardia and atrial tachycardia) is uncommon, together they represent 9% of all infant tachycardia (2.1 per 100 000 live births or 1:48 000 live births). Correct recognition of these tachycardias is important as they may cause tachycardia-mediated cardiomyopathy. The first two are unlikely to resolve in infancy and need a longer term management plan.

There is no evidence that the incidence of paediatric arrhythmia varies according to racial background, so our data are probably applicable to other populations.

Limitations

We excluded infants with long QT syndrome (LQTS) because none had an arrhythmia. LQTS can cause sudden death in infancy,[12] and any infants with LQTS who died suddenly will have been missed by this study. We also excluded prenatally diagnosed cases who had post-natal drug treatment but no post-natal recurrence – again because they did not have an arrhythmia. Prenatal diagnosis of tachycardia is generally limited to distinguishing supraventricular tachycardia from atrial flutter so the true mechanism is not known if there is no post-natal recurrence.

Conclusion

This report defines the population incidence of clinically significant arrhythmias presenting in infancy.

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