Incomplete right bundle branch block: a novel electrocardiographic marker for lone atrial fibrillation

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Aims

P-wave morphology and PR interval have both been previously associated with atrial fibrillation (AF). We hypothesized that incomplete right bundle branch block (IRBBB) would be associated with early-onset lone AF.

Methods and results

We conducted a case–control study comparing electrocardiographic (ECG) markers from patients with early-onset lone AF and from a healthy control population. We included 187 patients with early-onset lone AF and 383 healthy controls. Sixty-two lone AF patients were excluded from the study because of AF at the time of enrolment or because of the use of antiarrhythmic drugs. For the remaining 125 patients with paroxysmal or persistent lone AF (84% males, mean age 37), controls were matched on a 1:1 basis on the parameters gender and age. A significantly higher proportion of the lone AF population had an IRBBB compared with the subjects in the control group (33.6 vs. 10.4%; P < 0.001). In multivariable analysis adjusted for conventional risk factors, IRBBB was strongly associated with lone AF [odds ratio (OR) 5.43; 95% confidence interval (CI) 2.30–13.02; P < 0.001]. Lone AF patients had a significantly longer PR interval than the control group (175.1 vs. 160.9 ms; P < 0.001), but in multivariable analysis, every 10 ms increase in the PR interval was only borderline significantly associated with an OR of 1.15 (95% CI 0.99–1.32; P = 0.060) for lone AF.

Conclusion

We are the first to report that IRBBB is strongly and independently associated with early-onset lone AF.

Keywords

Lone AF • IRBBB • Brugada syndrome • Downsloping ST-segment • PR interval

Introduction

Atrial fibrillation (AF) is the most prevalent sustained cardiac arrhythmia. It is responsible for considerable morbidity and mortality, and its population prevalence has reached epidemic proportions, affecting almost 7 million patients in the European Union and the USA.1–4

In most cases, AF is associated with cardiac risk factors such as hypertensive, ischaemic, and/or structural heart disease.5,6 However, 10–20% of the patients suffering from AF are younger than 60 years of age and lack the traditional risk factors for AF. These patients are considered as having ‘lone’ AF.1 The mechanisms underlying AF are not fully understood, but a heterogeneous model based on the interaction of multiple substrates and triggers is thought to explain the disease. However, early-onset lone AF has been suggested to be a primary electrical disease caused by disturbances in transmembrane ionic currents. Of note, a genetic cause of these types of electrical disturbances is becoming increasingly recognized.7–9

Several studies have linked the genetic and molecular basis for AF with that of the rare Brugada syndrome (BrS). The incidence of AF among patients with BrS is thus between 6 and 38%.10,11 BrS is characterized by electrocardiographic (ECG) changes in the right precordial leads (V1–V3) that are similar in appearance to an incomplete right bundle branch block (IRBBB) combined with J-point elevation and a saddleback or curved downsloping
ST-segment (DSTS). However, it remains unknown whether AF and BrS patients in general share ECG features.

A National Heart, Lung, and Blood Institute workshop recently drew attention to the importance of AF prevention to help manage the increasing incidence of AF that is expected. Identifying and characterizing intermediate phenotypes of AF may help identify high-risk individuals prior to disease onset. Other investigators have previously demonstrated an association between P-wave duration, P-wave morphology, PR interval, and a patient’s risk of developing AF. In particular, longitudinal data from the Framingham Heart Study have demonstrated that PR interval prolongation is an independent predictor of AF. Data from the Framingham Heart Study have demonstrated that PR interval prolongation is an independent predictor of AF.17,18

When treating patients suffering from early-onset lone AF, we observed a surprisingly high proportion of ECGs that had evidence of IRBBB as well as DSTS in the right precordial leads. In light of these observations and the possible pathophysiological overlap between early-onset lone AF and BrS, the purpose of this study was to determine whether the presence of an IRBBB and a DSTS in the right precordial leads is associated with lone AF.

**Methods**

**Study design**

This case–control study was designed to investigate the ECG markers of AF in a cohort of patients with early-onset lone AF compared with healthy gender- and age-matched controls.

**Study subjects**

Lone AF patients from eight hospitals in the Copenhagen region of Denmark were included in the study. Only lone AF patients with disease onset prior to 40 years of age were included. Patients with structural heart disease (i.e., abnormal echocardiography), hypertension, diabetes, and/or metabolic diseases were excluded from the study. A detailed medical and medication history was obtained from all patients. All patients taking antiarrhythmic drugs (AADs), β-blockers, or calcium antagonists at the time of enrolment were excluded from the study. Patients were asked whether they had a family history of AF. Written informed consent was obtained from all enrolled patients.

A control population was collected from (i) blood donors (in collaboration with the Blood Bank at Copenhagen University Hospital, Rigshospitalet) and (ii) aviation pilots undergoing health examinations (in collaboration with the Department of Aviation Medicine at Copenhagen University Hospital, Rigshospitalet). Clinical information was evaluated to ensure that they were healthy and did not have heart disease, hypertension, pulmonary disease, or any metabolic disorders. The study protocol was approved by the local Ethics Committee (KF-01-313322).

**Electrocardiography**

A standard 12-lead surface ECG was recorded from all participating subjects at the day of enrolment. The first ECG recorded was included in the study, but in the case of poor quality of the first recording, a subsequent ECG was included. All ECGs were recorded in the same centre, with identical equipment, and according to identical guidelines. During recording, the participants were in the supine position. They were allowed to breathe freely but were not allowed to speak. Electrocardiograms were recorded at a paper speed of 25 mm/s and 1 mV/cm calibration. The PR (PQ) interval, QT interval, existence of left bundle branch block, right bundle branch block (RBBB), IRBBB, DSTS in leads V1 or V2, and BrS or BrS-like ECG patterns were determined.

All measurements were performed manually using a calliper. Intervals were measured using the longest interval found in any lead and rounded to the nearest 1/100th of a millisecond. The QTc was calculated using Bazett’s formula (QTc = QT/(√RR)). Left bundle branch block and RBBB were defined according to the Minnesota Code Manual of Electrocardiographic Findings. Incomplete right bundle branch block was defined as the presence of an RSR′ or RSR′ configuration in leads V1 or V2 and a QRS interval <120 ms in leads I, II, III, aVl, and aVF. Downsloping ST-segment was defined as the presence of a continuously descending ST-segment in lead V1 and/or V2 from the J-point to the nadir of the negative T-wave without the presence of any isoelectric area in the ST-segment. Brugada’s syndrome type 1 pattern was defined as a coved ST-segment elevation ≥2 mm (0.2 mV) followed by a negative T-wave observed in >1 right precordial lead (V1–V3). Brugada’s syndrome type 2 pattern was defined as a ST-segment elevation with a saddleback appearance and a high takeoff ST-segment elevation of ≥2 mm, a trough displaying >1 mm ST elevation, and then either a positive or biphasic T-wave in ≥1 right precordial leads. Brugada’s syndrome-like ECG patterns were defined as ECGs that bore close resemblance to a BrS type 1 or 2 pattern. Examples of the ECG classification system that was used are shown in Figure 1.

Only ECGs recorded in sinus rhythm (SR) was included. Thus, all patients with AF at the time of ECG recording were excluded from the study. As a result, patients with permanent AF, atrial tachyarrhythmias, or paced rhythms were excluded.

**Reproducibility**

The study was not blinded, but to test the inter-rater reproducibility and bias of ECG interpretation, a comparison between an investigator (J.B.N.) and an external ECG interpreter was carried out on the ECG parameters IRBBB and DSTS. The external ECG interpreter was only given the written definitions stated above including Figure 1 and was completely blinded to the source of the ECGs.

**Statistical analysis**

A conditional logistic regression model was used to examine the association between ECG markers and lone AF. Controls were randomly matched to cases on a 1:1 basis on the parameters gender and age, using 5-year age groups. Non-matched controls were discarded.

Potential markers were analysed both in a univariate and multivariate model adjusted for body mass index (BMI), heart rate, and mean arterial blood pressure [(MAP = diastolic blood pressure + 1/3 systolic blood pressure − diastolic blood pressure)].

Cohen’s kappa coefficient (k) was used to test the inter-rater agreement for ECG interpretation.

Data are presented as means ± standard deviations unless otherwise indicated. Differences between means or medians were assessed using the unpaired Student’s t-test or the Wilcoxon rank-sum test. Differences between proportions were assessed using the χ² test.

**Results**

**Study cohort**

A total of 187 patients with lone AF were initially enrolled in the study. Twenty-three patients (12%) were excluded because of...
non-SR ECGs and 39 (21%) were excluded because of being on AADs, β-blockers, or calcium antagonists. These exclusions resulted in a final study population of 125 patients with paroxysmal or persistent lone AF. The patients’ age at disease onset ranged from 16 to 39 years. All included AF patients had a normal echocardiography.

The control population comprised 157 blood donors and 226 aviation pilots (total 383). All of the controls were healthy and evaluated with clinical history and an ECG. After matching, 125 controls were kept and 258 controls were discarded. All included individuals were of Danish/Caucasian ethnicity.

Baseline characteristics
The baseline characteristics of the included individuals are listed in Table 1. The PR interval was significantly longer in the AF cohort than in the control population (173.9 vs. 162.8 ms, respectively; $P = 0.005$), whereas the QRS and QTc intervals were similar between the two groups. All included individuals had a QRS interval <120 ms. A significant higher proportion of the lone AF population had an IRBBB compared with controls (33.6 vs. 10.4%, respectively; $P < 0.001$), and a DSTS was also identified significantly more often in the AF cohort than in the control group (19.2 vs. 4.8%, respectively; $P < 0.001$). Brugada’s syndrome-like ECGs were only found in the lone AF population (4.8 vs. 0% in the controls; $P = 0.013$), all of whom had ECG findings indicative of or similar to a BrS type 2 pattern (Figure 1). A clinical suspicion of BrS was not raised in any of these patients.

Downsloping ST-segment and IRBBB were closely correlated with one another. A total of 47% of subjects with an IRBBB also had a DSTS, and only 2% of the subjects with a DSTS did not have an IRBBB.
Electrocardiographic markers of atrial fibrillation

The presence of an IRBBB and a DSTS was significantly associated with AF in a univariate model adjusted for heart rate, BMI, and MAP, whereas the PR interval was only borderline significantly associated (Table 2).

Upon multivariable analysis, we found that IRBBB was still significantly associated with early-onset lone AF with an odds ratio (OR) of 5.43 [95% confidence interval (CI) 2.30–13.02; \( P < 0.001 \)] (Table 2). Because of the close correlation seen between IRBBB and DSTS, DSTS was not included in the multivariable model. The PR interval was included in the multivariable model because of the borderzone association with lone AF and the fact that PR interval prolongation previously has been associated with increased risk of AF.\(^{17,18,22}\)

**Inter-rater agreement analysis**

An inter-rater agreement was tested for the coding of IRBBB and DSTS. The interpretation of 150 randomly selected ECGs was carried out by a blinded external rater and compared with the investigator findings. With respect to IRBBB, there was agreement in 98.7% of the cases (with 68.8% agreement expected by chance) resulting in a \( \kappa \) index of 0.96, which corresponds to 'almost perfect agreement' according to Landis and Koch.\(^{23}\) Criteria. With respect to DSTS, there was a 94.0% agreement (with 78.3% agreement expected by chance), resulting in a \( \kappa \) index of 0.72, which corresponds to 'substantial agreement'.\(^{23}\)

**Discussion**

This study is the first to report that the ECG finding of IRBBB is strongly and independently associated with early-onset lone AF. Incomplete right bundle branch block has previously been associated with the presence of an ostium secundum atrial septal defect as well as arrhythmogenic right ventricular cardiomyopathy.\(^{4,25}\) However, a recent European Society of Cardiology report stated that when IRBBB is present as an isolated ECG finding, it does not require further evaluation in athletes.\(^{26}\)

Reviewing the literature, we found no consensus about how to define IRBBB. In fact, the majority of studies that discuss IRBBB refrain from specifying a definition due to our belief that the presence of any r′ was allowed to be smaller than, equal to, or larger than the initial R-wave in either lead V1 alone or both leads V1 and V2.\(^{29,30}\) We selected a broad configuration only,\(^{19}\) whereas in others, the amplitude of the r′ was allowed to be smaller than, equal to, or larger than the initial R-wave in either lead V1 alone or both leads V1 and V2.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ in the right precordial leads could be a marker for cardiac electrical disturbance and a possible indicator of early-onset lone AF. Our definition of IRBBB was strongly reproducible in a blinded inter-rater agreement study (\( \kappa = 0.96 \)).

The prevalence of IRBBB in the general population has been estimated to be around 3–7%. Thus, the 10% prevalence we found in the control group is slightly higher than the prevalence that has been reported in previous studies. However, the prevalence of IRBBB depends on both the definition used and the composition of the study population. Incomplete right bundle branch block has a striking male predilection and is more prevalent in athletes participating in endurance sports.\(^{20,26–28}\)

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**Table 1** Baseline clinical characteristics of the study population (\( n = 250 \))

<table>
<thead>
<tr>
<th></th>
<th>Cases (( n = 125 ))</th>
<th>Controls (( n = 125 ))</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender [% (( n ))]</td>
<td>84 (105)</td>
<td>84 (105)</td>
<td>1.000</td>
</tr>
<tr>
<td>Age at inclusion [years (IQR)]</td>
<td>37 (32–42)</td>
<td>36 (33–42)</td>
<td>0.856</td>
</tr>
<tr>
<td>BMI (kg/m(^2))*</td>
<td>26.4 (4.4)</td>
<td>24.8 (2.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blood pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>131.4 (12.2)</td>
<td>131.2 (10.7)</td>
<td>0.891</td>
</tr>
<tr>
<td>Diastolic</td>
<td>79.4 (7.8)</td>
<td>74.8 (7.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age at onset of AF [years (IQR)]</td>
<td>30 (13)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>AF category [% (( n ))]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>67 (84)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Persistent</td>
<td>33 (41)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Family history of AF [% (( n ))]</td>
<td>37 (46)</td>
<td>Not known</td>
<td>—</td>
</tr>
<tr>
<td>First-degree relatives with AF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECG characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate (b.p.m.)</td>
<td>66.4 (13.1)</td>
<td>63.7 (10.2)</td>
<td>0.072</td>
</tr>
<tr>
<td>PR interval (ms)</td>
<td>173.9 (30.8)</td>
<td>162.8 (23.3)</td>
<td>0.005</td>
</tr>
<tr>
<td>QRS interval (ms)</td>
<td>96.7 (9.2)</td>
<td>97.3 (9.7)</td>
<td>0.698</td>
</tr>
<tr>
<td>QTc interval*</td>
<td>400.7 (27.0)</td>
<td>401.8 (23.8)</td>
<td>0.729</td>
</tr>
<tr>
<td>IRBBB [% (( n ))]</td>
<td>33.6 (42)</td>
<td>10.4 (13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DSTS [% (( n ))]</td>
<td>19.2 (24)</td>
<td>4.8 (6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Brugada-like ECG findings [% (( n ))]</td>
<td>4.8 (6)</td>
<td>0.0 (0)</td>
<td>0.013</td>
</tr>
</tbody>
</table>

All included ECGs were obtained during SR, and patients without an SR ECG were excluded from the study. IQR, inter-quartile range; IRBBB, incomplete right bundle branch block; DSTS, downsloping ST-segment in V1 and/or V2.\(^{29,30}\) We selected a broad configuration only,\(^{19}\) whereas in others, the amplitude of the r′ was allowed to be smaller than, equal to, or larger than the initial R-wave in either lead V1 alone or both leads V1 and V2.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ was allowed to be smaller than, equal to, or larger than the initial R-wave in either lead V1 alone or both leads V1 and V2.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ in the right precordial leads could be a marker for cardiac electrical disturbance and a possible indicator of early-onset lone AF.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ in the right precordial leads could be a marker for cardiac electrical disturbance and a possible indicator of early-onset lone AF.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ in the right precordial leads could be a marker for cardiac electrical disturbance and a possible indicator of early-onset lone AF.\(^{29,30}\) We selected a broad definition due to our belief that the presence of any r′ in the right precordial leads could be a marker for cardiac electrical disturbance and a possible indicator of early-onset lone AF.\(^{29,30}\)

**Table 2** Odds ratios of ECG markers for lone AF

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio (95% CI)</th>
<th>( P )-value</th>
</tr>
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<tbody>
<tr>
<td>Univariate*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR interval</td>
<td>1.12 (0.99–1.27)</td>
<td>0.064</td>
</tr>
<tr>
<td>QRS interval</td>
<td>0.97 (0.73–1.30)</td>
<td>0.846</td>
</tr>
<tr>
<td>QTc interval</td>
<td>0.95 (0.84–1.08)</td>
<td>0.465</td>
</tr>
<tr>
<td>IRBBB</td>
<td>5.15 (2.21–11.97)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DSTS</td>
<td>5.48 (1.78–16.87)</td>
<td>0.003</td>
</tr>
<tr>
<td>Multivariable*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR interval</td>
<td>1.15 (0.99–1.32)</td>
<td>0.060</td>
</tr>
<tr>
<td>IRBBB</td>
<td>5.43 (2.30–13.02)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Adjusted for body mass index, heart rate, and mean arterial blood pressure. For ECG intervals, the odds ratios that are presented are for 10 ms increases in the respective intervals (i.e. PR, QRS, and QTc).

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\(^{1}\)Corrected QT interval (QTc), Bazett’s formula \( = (QT \text{ interval})/(\sqrt{RR \text{ interval}}) \).
The term IRBBB implies a partial block in the right Purkinje system. Few studies have sought to identify the aetiology underlying IRBBB. In a 1971 canine study, Moore et al. reported that IRBBB may reflect a developmental variation in the thickness of the right ventricular free wall, rather than an abnormality of the right ventricular conduction system in individuals without apparent heart disease. They also suggested that this developmental variant appeared to have a genetic basis. Data from Liao et al. however, suggest that IRBBB predisposes an individual to the development of a complete RBBB or complete atrioventricular block later in life, indicating that there is a common pathogenesis between these phenotypes. The same authors mentioned an increase in the prevalence of IRBBB from the early 40s to late 50s. To further add to the confusion, the results of a cross-sectional study of athletes that was performed by Pelliccia et al. reported a decline in the prevalence of IRBBB from adolescence to the mid-30s. This could be due to differences in the definition of IRBBB and the composition of the study populations. The kind of IRBBB observed early in life may also be of a different aetiology than the one found in the elderly, with only the latter being a sign of increased fibrosis in the Purkinje system.

Some case reports indicate that type 1C AADs (i.e. propafenone and flecainide) can induce an IRBBB. For this reason, we excluded all patients taking AADs, β-blockers, and calcium antagonists at the time of enrolment.

There are several potential explanations for the observed strong association between IRBBB and early-onset lone AF.

Incomplete right bundle branch block may be an early sign of fibrosis in the Purkinje system and may thus be a marker for the ‘physiological age’ of the conduction system. Fibrosis of the atrial tissue predisposes an individual to developing AF, and IRBBB could be a simple marker for this underlying pathophysiology. However, our cohort of young lone AF patients showed no other signs of cardiac or vascular disease. A wider QRS interval would have been expected if patients had Purkinje system dysfunction, which was not the case in our study population.

Genetic mutations and polymorphisms in the gene encoding the α-subunit of the cardiac sodium channel gene SCN5A have been associated with lone AF. Some variations in SCN5A may be capable of accelerating the process of fibrosis in the ventricular myocardium and Purkinje system, leading to a bundle branch block. Thus, genetic variation in SCN5A or other genes responsible for the cardiac conduction could be the underlying cause for both lone AF and IRBBB, although evidence supporting this hypothesis is currently lacking.

The prominent *I* α current and a loss of the dome of the cardiac action potential in both the right ventricular epicardium and the atria are thought to at least partially form the basis for the aetologically overlap between AF and BrS. A possible alteration in the *I* α current in the Purkinje system may link AF and BrS with the *r*’ in the IRBBB. However, this hypothesis lacks evidence, and the appearance of the *r*’ or J-wave in BrS is different in morphology from the one that was observed in the present AF study (Figure 1).

On the basis of the findings of Moore et al., who suggested that IRBBB was a marker for development variation in the thickness of the right ventricular free wall, structural variations in the heart could underlie IRBBB and also pose a risk factor for developing AF at a young age. Interestingly, genetic variation likely to be related to the gene PITX2, which is involved in the embryogenesis of the heart, increases a patient’s risk of developing AF.

A high proportion (37%) of the lone AF patients had one or more first-degree relatives with AF, even though the family members were still relatively young. This proportion is slightly higher than previously reported by Fox et al. (30% with paternal AF), who investigated a large cohort (mean age 47 years) of both lone and conventional AF patients. The two studies are not directly comparable, and our apparently higher proportion of familial AF could be due to an increased genetic influence in early-onset lone AF patients compared with more common forms of AF.

We noticed a high prevalence of BrS-like ECG patterns in our lone AF cohort. In line with this observation, recent work by Pappone et al. describes a high prevalence of latent BrS in patients with early-onset lone AF. Whether our finding is due to latent BrS is unknown. However, a clinical suspicion of BrS was not otherwise raised in any of the patients with BrS-like ECG findings.

Downsloping ST-segments were observed significantly more frequently among the AF patients than in the control population, and we speculated that this ECG finding could also be an independent marker for early-onset AF. However, the presence of a DSTS was highly correlated with the presence of an IRBBB, which indicates that a common mechanism may underlie both DSTS and IRBBB.

In line with the findings of other investigators, we found that the PR interval was significantly longer in the AF patients compared with healthy individuals. However, when adjusted for heart rate, MAP, and BMI in a multivariable model, the PR interval was only borderline significantly associated with lone AF. This lack of significance in the multivariable model could be a matter of low statistical power.

**Study limitations**

This was a case–control study, and its findings should be replicated in a large, community-based cohort study to determine whether IRBBB can predict the onset of AF later in life. We used a highly selected group of early-onset lone AF patients, and it is therefore unknown whether these data can be applied to the general AF population. The control population differed from the AF group with regards to some baseline characteristics, but we were able to adjust for this in our analyses. The primary investigator was not blinded to the source of the ECG, but a blinded inter-rater agreement analysis was performed to evaluate bias.

Both IRBBB and AF are associated with participation in endurance sports. Unfortunately, we were unable to adjust for this association because data regarding sports participation were not consistently obtained in our populations. The control population consisted of healthy, physically active blood donors and aviation pilots. Furthermore, the controls had lower BMIs than the AF cases, indicating that the AF patients lived a more sedentary lifestyle.

**Conclusions**

This study is the first to report that IRBBB is strongly and independently associated with early-onset lone AF with an OR of 5.43 (95% CI 2.30–13.02; *P* < 0.001).
Acknowledgments

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Conflict of interest: none declared.

Funding

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References


