QT Dispersion in Children with Congenital Heart after Open-Heart Surgery Disease

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Abstract

Background- A number of publications has shown a relation between increased QT dispersion and death from a cardiac cause. However, there are no published data on the value of QT interval dispersion after open-heart surgery in the pediatric age group.

Methods- Three electrocardiograms (pre-operation, on the day of operation and the second day post-operation) were obtained from 18 children (11 males, 7 females), three to 14 years of age. Measurements were carried out from standard 12- lead ECGs recorded at a speed of 25 mm/s at rest. The QT and preceding RR intervals of at least one sinus beat (range one to three) were measured in a range of nine to 12 leads, and the mean QT and RR intervals were calculated. The corrected QT interval was calculated by Bazett's method ($QTc = QT/\sqrt{RR}$). QT intervals were measured from the onset of the QRS complex to the end of the T wave. Dispersion of the QT and QTc were defined by the difference between the maximum and minimum QT and QTc intervals occurring in any of the 12 leads.

Results- The mean QT dispersion in patients before surgery was 53 ± 22 ms, 72±31 ms on the day of operation and 65±27 one day after operation, and mean QTc dispersion before surgery was 62±22 ms, 95±27 ms on the day of operation and 97±41 ms on the day after operation. There was a significant increase in mean QT and QTc immediately after surgery ($p<0.001$). Although it decreased on the first day after surgery, it remained significantly high as compared to before surgery ($p<0.02$).

Conclusion- QT interval dispersion may increase after open-heart surgery, which may result in death following an arrhythmia. Open-heart surgery may have an independent role in the genesis of QT dispersion prolongation and should be considered as one of the mechanisms of arrhythmia after surgery ***(Iranian Heart Journal 2005; 6 (1,2): 55-59).***

Key words: QT dispersion ■ open-heart surgery ■ arrhythmia

QT interval dispersion is an indirect measure of the heterogeneity of ventricular repolarisation.[1,2] A potential application of this inter-lead difference from standard 12-lead electrocardiograms (ECGs) was first proposed by Day et al. in 1990.[3]

More recently, there has been an increasing interest in what has become known as QT dispersion, which is defined as the difference between the maximum and minimum QT interval of the 12- lead ECG.[4] A number of publications have shown a relation between increased QT dispersion and death from a cardiac cause.[5-7] Other studies have shown that QT dispersion can be reduced as a result of certain drug treatments.[8,9]

On the other hand, increased QT dispersion has been shown not to be associated with increased cardiac death in patients with idiopathic dilated cardiomyopathy.[10]

It has also been suggested that increased dispersion has been reported as a non-invasive marker of an electrophysiological arrhythmogenic substrate, and it has been associated with high risk of ventricular arrhythmias and sudden death in various cardiac disorders.[11-12] Altogether, within the last decade, QT dispersion has been proposed as a descriptor of ventricular repolarization and, as such, as a potential prognostic tool in the detection of future ventricular tachyarrhythmic events and death.[13] In a recent study, it has been found that not only QT-interval dispersion but also other indices measured on the whole QRS-T complex, especially the JT index and T peak-T end, could be used in the quantitative assessment

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of the dispersion of ventricular repolarisation.[14] However, there has been only a limited amount of data published on the use of indices other than the QT interval, and also there are few published data on the value of QT interval dispersion in the pediatric age group. Hence, this study was carried out to determine the changes of QT, QTc, JT and JTc dispersion in children with congenital heart disease who undergo open-heart surgery.

Methods

Three electrocardiograms (pre-operation, on the day of operation and the second day post-operation) were obtained from 18 children (11 males, 7 females), three to 14 years of age (mean: 8.4 ± 3.4 years). The children had at least one type of congenital heart disease necessitating open-heart surgery.

Study Protocol

Measurements were carried out from standard 12- lead ECGs, recorded at a speed of 25 mm/s at rest. A one-channel electrocardiographic recorder (Hewlett Packard, model 4745 A) was used. The QT and preceding RR intervals of at least one sinus beat (range one to three) were measured in a range of nine to 12 leads, and the mean QT and RR intervals were calculated. The corrected QT interval was calculated by Bazett's method ($QTc = QT/\sqrt{RR}$).[15] The mean QT and the mean RR were used to calculate the mean QTc for each lead. Heart rate was derived from the mean of the RR intervals. The QT and RR intervals were measured manually with calipers by a single observer. QT intervals were measured from the onset of the QRS complex to the end of the T- wave. The end of the T- wave was defined as the point of return to the isoelectric line. When a U wave was present, the QT interval was measured to the nadir of the curve between the T and U wave.[16] Leads with non indeterminate end of the T- wave were excluded from the calculation. Dispersion of the QT and QTc were defined in two ways: (1) the difference between the maximum and minimum QT and QTc intervals occurring in any of the 12 leads (QTD, QTcD), and (2) the standard deviation of the QT and QTc interval in the leads that could be measured (QT-SD, QTc-SD).[17] RR variation was also calculated in a same manner (RRD and RR-SD, respectively).

All the data are expressed as mean ± SD. Paired and unpaired Student's *t* tests were used where appropriate. Correlations were assessed by Pearson's coefficients. A two-tailed p value < 0.05 was considered significant.

Results

The study group consisted of 18 children, 11 of whom were male and the remainders were female. The mean age was 8.4 ± 3.4 years, with the mean weight of 20.5 ± 7.6 kg. All the patients in the study group had undergone open-heart surgery due to one or more of the following congenital heart diseases: tetralogy of Fallot, ventricular septal defect, atrial septal defect and partial AV canal with patent foramen ovale or patent ductus arteriosus. The ECG data before, immediately after and one day after open-heart surgery are presented in Table I.

Table I. QT measurements before, just after and one day after open-heart surgery.

	Before	Just after	One day after	P values*
RR mean (ms)	644(101	507(90)	563(115)	p<0.001
QT mean (ms)	342(38)	336(34)	336(79)	p<0.001
QT Dispersion (ms)	53(22)	72(31)	65(27)	p<0.001
QTc mean (ms)	424(33)	476(32)	437(88)	p<0.001
QT cDispersion (ms)	62(22)	95(27)	97(41)	p<0.001
JT mean (ms)	256(27)	257(24)	266(31)	NS
JT Dispersion (ms)	51(21)	57(28)	68(30)	NS
JTc mean (ms)	337(25)	363(28)	362(33)	p<0.001
JT cDispersion (ms)	62(26)	97(41)	86(26)	p<0.001

* p values refers to comparison between before and just after surgery measurements.

The mean QT dispersion in patients before surgery was 53 ± 22 ms, 72±31 ms on the day of operation, and 65±27 ms on the day after operation.
QTc dispersion before surgery was 62±22 ms, 95±27 ms on the day of operation, and 97±41ms on the day after operation.

There was a significant increase in QT and QTc dispersion immediately after surgery ($p<0.001$).
Although it decreased on the first day after surgery, it remained significantly high as compared to before surgery ($p<0.02$).
Individual QT dispersion values are shown in Fig. 1 before and one day after open-heart surgery.
QT dispersion values have shown to be increased in two-thirds of patients and to be decreased in the rest.

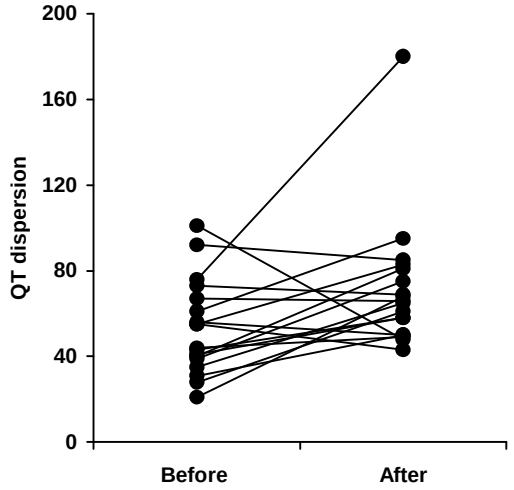

Fig. 1. Individual QT dispersion values before and one day after open-heart surgery.

Discussion

It is well-established that ventricular repolarization characteristics play an important role in arrhythmogenesis.[18] In the assessment of ventricular repolarization, prolongation of the QT- interval duration is known to contribute to the triggering of arrhythmias.[19] The dispersion of ventricular repolarisation, measured from the surface ECG and defined as the interlead variability of the QT-interval, has been reported as a new method for analyzing ventricular repolarization. Dispersion of repolarization is thought to reflect regional heterogeneity of the recovery process within the myocardium,

which is believed to be important in the genesis of ventricular arrhythmias.[20] The concept that QT interlead variability reflects the dispersion of ventricular repolarization is supported by the close correlation between changes in dispersion of repolarization from ventricular monophasic action potential recordings and changes in QT-interval variation produced by ventricular pacing.[1] Furthermore, dispersion of ventricular repolarization has been shown to be increased in various cardiac disorders known to be complicated by ventricular arrhythmias, such as long QT syndrome, drug toxicity and dilated and hypertrophic cardiomyopathies.[12] There are few published data on the value of QT interval dispersion in the pediatric age group. In the study of Macfarlane et al.[21] in the pediatric age group, overall QT dispersion was 24.52±8.7ms (10-44 ms). This study showed that open-heart surgery increased QT-interval dispersion in children. One of our patients who showed the most increment in QT dispersion died with arrhythmia after surgery. Little is known about the etiology of increased QT dispersion in patients after open-heart surgery, but sympathetic tone and excitation-contraction coupling may be important. As in the majority of studies of QT dispersion, all QT-intervals in our study were measured manually. There is evidence that manual measurement is superior to automatic measurement of QT dispersion, which usually needs some form of manual editing[22] and gives different results.[23]

Conclusion

We found that in children, QT-interval dispersion might increase after open- heart surgery, which may result in death following an arrhythmia. Hence, open- heart surgery may have an independent role in the genesis of QT dispersion prolongation and should be considered as one of the mechanisms of arrhythmia after surgery.

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