

# Automatic Detection of Q-T interval in ECG using MATLAB Tool

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## Research Article

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# **Detection of Q-T Interval in ECG using MATLAB**

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## **ABSTRACT**

While measurement of QT prolongation in electrocardiogram (ECG) is important to clinical applications, but it is quite difficult to evaluate the performance of QT measurement algorithms using clinical ECGs because the real values of the Q-point and T-end point changes are usually unknown and is difficult to detect.

This research paper deals with the Abnormality Detection and its analysis using MATLAB tool software. In this paper, abnormality which is in concern is known as QT prolongation. Due to prolongation or extension of QT interval in the ECG graph obtained from abnormal patient, known as QT syndrome is caused.

For the analysis purpose, Large number of data has been taken from QT database and MIT-BIH database. Some of the other useful data were also obtained from other useful sources such as ECG wave maven. In this paper, we have dealt only with the detection of QT interval and its detection. A MATLAB algorithm has been generated which in turn detects the Q-wave and T-end point corresponding to its input samples.

This algorithm is designed and analyzed with more than 100 samples taken from the various data base sources. It detects onset of the Q-wave and T-end point which in turn is used to calculate QT interval of the analyzed ECG sample.

**Keyword:** Abnormality, Detection, Q-T points, Q-T Syndrome, Algorithm, MATLAB.

## **INTRODUCTION**

The QT interval is the time interval between the onset of the Q wave and the offset of the T wave in an Electrocardiogram (ECG). It corresponds to the interval of the beginning of ventricular depolarization and the termination of ventricular repolarization. Hence, the QT interval is a useful parameter as an index of the ventricular repolarization duration (VRD) and therefore used for the diagnosis of ventricular arrhythmias such as long QT syndromes. Besides pathological causes, the prolongation of QT interval may also owe to an adverse drug reaction.

Some cardiac drugs (for example, Sotalol, Dofetilide, and Jbutilide) and non-cardiac drugs (for example, Erythromycin and Cisapride) may delay myocardial cell repolarization and result in the generally known drug-induced QT prolongation . Drugs related to the QT interval prolongation may increase the risk of deadly ventricular arrhythmias.

Within past years, several cases of cardiac death due to drug-caused prolongation of QT interval have been reported . As a result, drugs with similar side-effects have been withdrawn from the market or required to provide black box warnings in the drug's prescribing information. The US Food and Drug Agency (FDA) recommended pharmaceutical companies that all new drugs should be tested for their potential QT interval prolonging effects in the early research and development stage. As it is hard to accurately estimate the absolute value of QT interval, the drug-induced variation of QT interval before and after the pharmaceutical delivery is a practical index for the investigation of drug-induced pro-arrhythmic risk.

To estimate the QT interval from a single lead ECG, we need to measure the onset of QRS complex and the offset of T wave in each cardiac cycle. Compared with the T-wave end detection, the onset of QRS involute can be easily and accurately obtained before the R-wave. Therefore, we focused our study on the noise sensitivities of the algorithms for the detection of T wave offset point. We select six typical methods, including the threshold method, area method, slope method, differential method and wavelet transform (continuous wavelet transform and discrete wavelet transform) based method.

We provide a Q-T interval detection algorithm depending upon the Thresholding method of the ECG signal. Our approach has the following advantages:

- a) it is unresponsive to morphological variations of QRS complexes and T-waves;
- b) it is insensitive to ECG baseline wandering;
- c) it is computational efficient.

Prolongation of QT interval is not straightforward to estimate because the mundane QT intervals vary inversely with the beating frequency. For this reason, the absolute quantifications need to be redressed. Bazett's formula (Indik et al, 2006) is generally utilized for this rectification, albeit it has some constraints and should be used only within the mundane range of beating rates (Dogan et al, 2005).

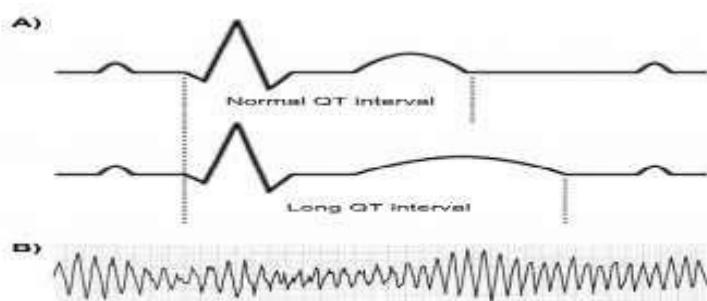


Fig. 1 Shows normal and prolonged QT interval.

According Bazett's formula, a rectified QT interval (QTc) results from dividing the QT time by the square root of the beating rate ( $QTc = QT/\sqrt{BR}$ ). In integration to beating rate dependence, the QT interval varies during the 24 hours in a day due to a number of factors, including circadian rhythms and impulses from the autonomic nervous system (Dogan et al, 2005). In integration, the threshold values of a mundane and protracted QTc interval are remotely different 59 depending on the gender.

## METHODOLOGY

In the study of ventricular activity, it is paramount that the QT interval is quantified correctly. Consequently, an algorithm to accurately detect QRS intricate beginning points and T wave end points is of great consequentiality to compute QT intervals. various methods for automatic electrocardiogram T-wave detection and QT-interval evaluation have been developed [8] [6]. While beginning of the QRS complex can be quantified with good precision due to its higher frequency content, the T wave end presents more preponderant difficulties. Presently, the algorithms can be divided into two parts, namely, threshold based algorithms and algorithms stated on intersection of slope as well as an isoelectric line [4].

In the threshold method, the threshold can be obtained from a given percentage of the T-peak or the derivative of the T peak, and the intersection is based on the threshold level with the T-wave. The slope methods are stated on the intersection of the maximum T-wave slope after the T-wave peak in reference with the isoelectric line in the TP segment. Several methods for the quantification of the cessation and, apex of the T wave are reviewed and compared in this chapter.

Quantification methods[8] compared here include:

- A. **Threshold Method (TH):** The point at which the T wave intersects a threshold level[8].
- B. **Derivative Threshold (DTH):** The point at which the derivative of the T-wave intersects a threshold point on T-wave[8].
- C. **Slope Intercept (SI):** The intersection of the maximum slope of T- wave and the iso-electric line[8].
- D. **Least squares Intercept (LSI):** The intersection of a line fitted by least squares at the maximum slope of the T wave and an isoelectric line[8].
- E. **T Wave Area (TA):** The total area of the T wave is considered and threshold is fine-tuned at 90% of the total area. The point at which the threshold intersects with the baseline of ECG , the point is detected as the T-wave end point[8].
- F. **Wavelet Detection Method (WD):** This method decomposes a signal into its components predicated on different scales. The detection of QRS beginning, T-peak and Incline depend upon the maximum absolute method and zero crossings of the mother wavelet transform at characteristic scales. The phases of the signal are preceded by the phases of the mother wavelet transform[8].

## ALGORITHM

In this study of QT interval and its relation to the abnormality caused by its prolongation resulting in arrhythmia known as QT syndrome, different methods were reviewed.

Thresholding method is used in this study to detect the QT interval by calculating Q-point and T-end point i.e onset of QRS complex and offset of the T-wave in

ECG sample. The Algorithm designed in MATLAB indicates desired points in each beat of a sample. Flow chart showing the steps utilized in our study to evaluate the different ECG sample and detection of various points is given below

The algorithm was divided into three main categories:

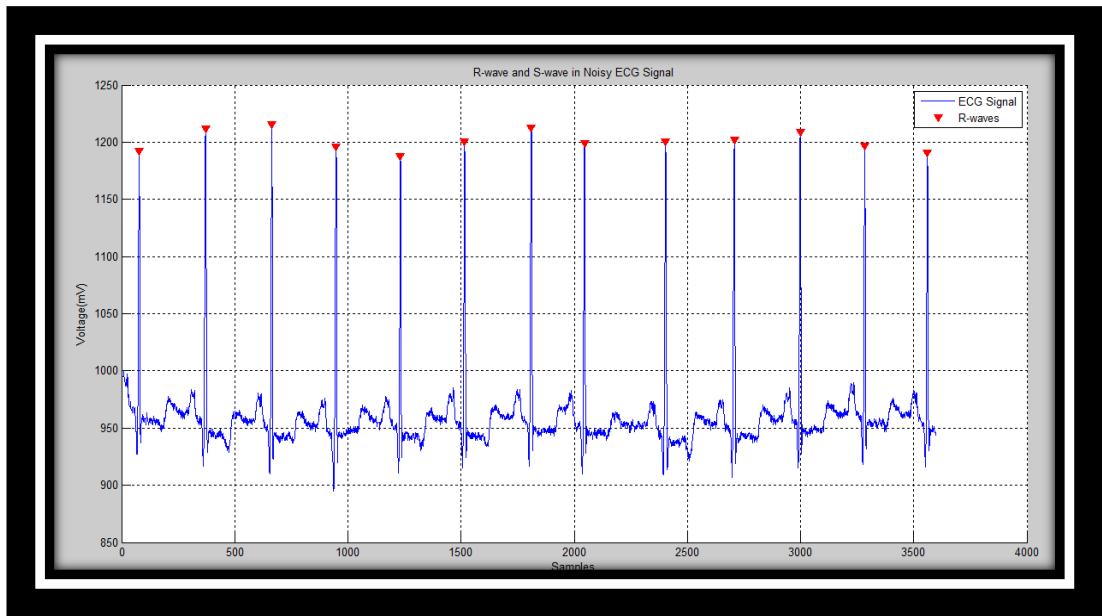
- a. Filtering and Differentiation Process
- b. R wave Detection
- c. Tmax and Tend Detection

First of all, smooth ECG signal is obtained through s-golay filter and then thresholding of peaks is done by optimizing the algorithm in such a way that the threshold selected in the algorithm takes these Q-point and T-end point into its consideration.

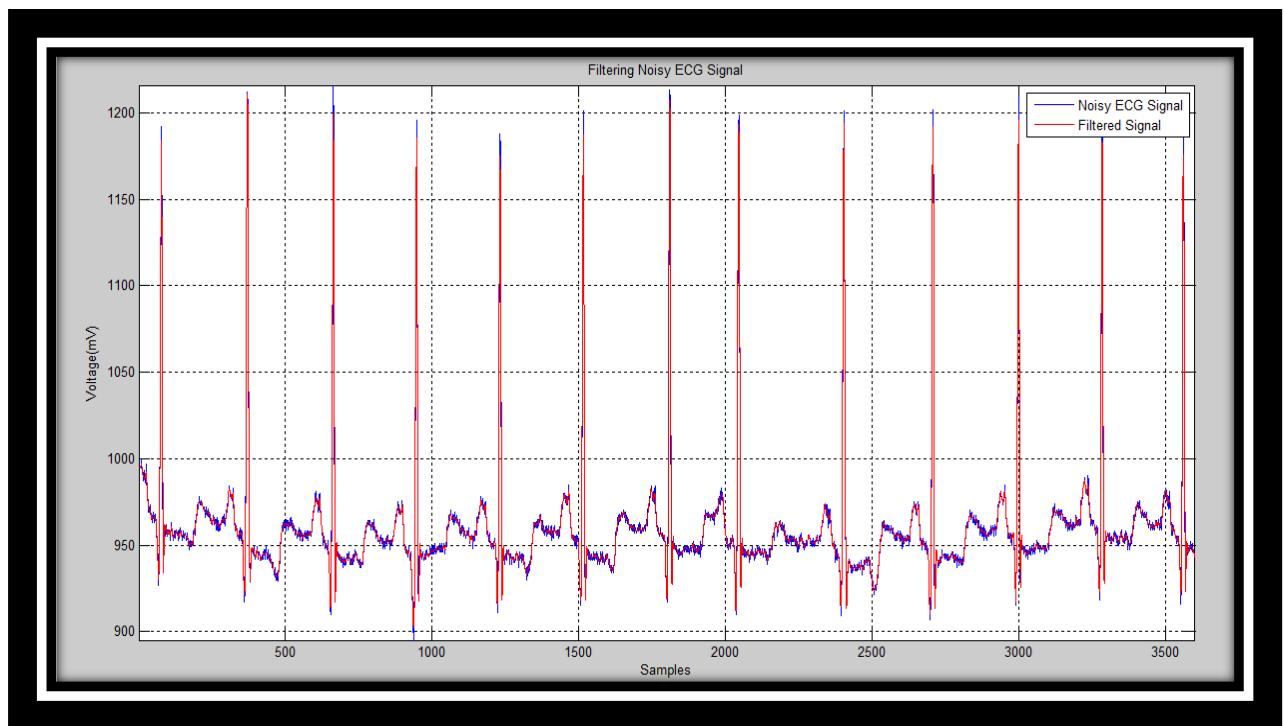
Q-T interval detection is done by detecting the Q-point and T-end point in a particular beat of the given sample which is to be analyzed.

Detection of these points is done with the help of given Algorithm which is divided into 5 parts:

- a. digitized data samplesfrom physio-netdatabases
- b. smoothing and filtering noisy ECG signal the given sample
- c. thresholding the particular sample with the calculated mean value
- d. finding Q,R,T-end point in the given loadedsample
- e. detection of Q-wave and T-end point values.

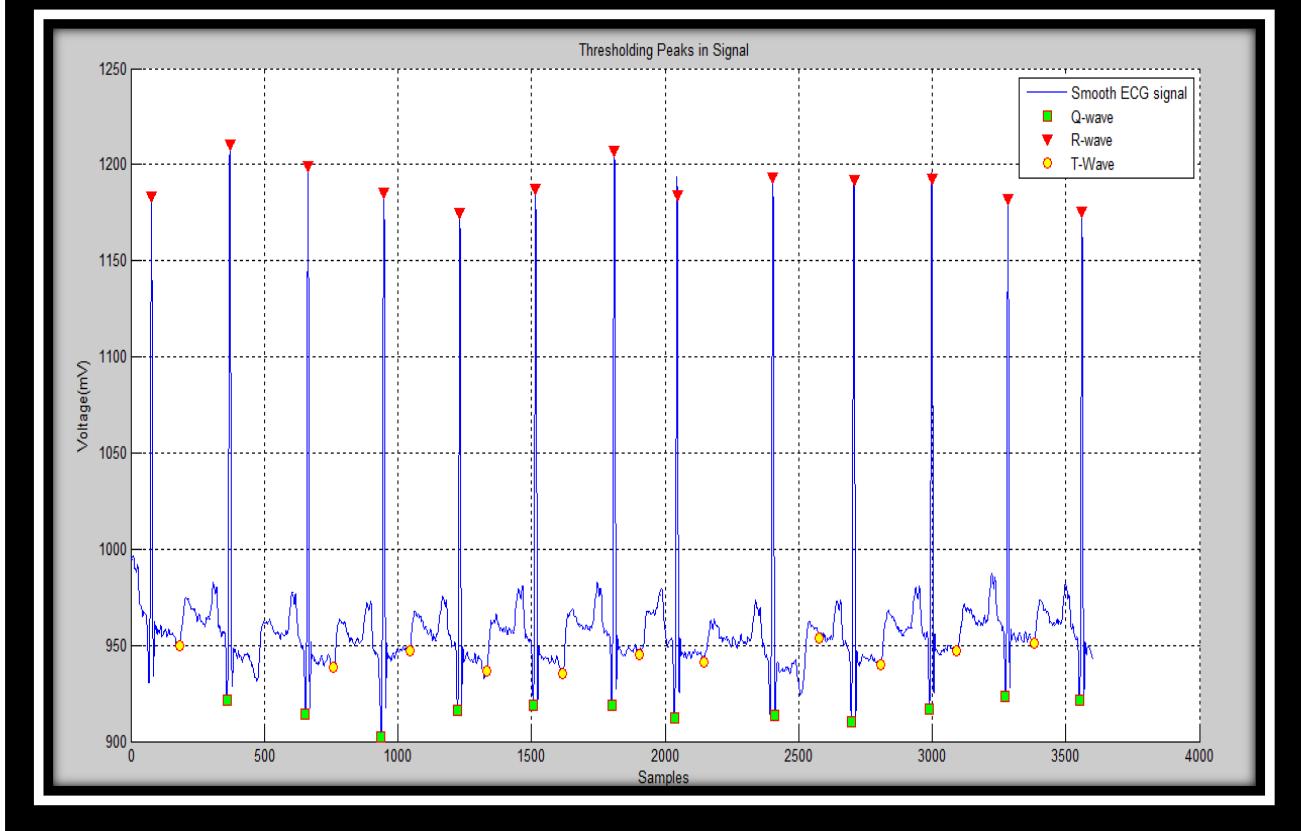


**R - wave detection in signal**



**filtered signal of given ECG samples**

## Q-wave and T-end point detection



## RESULTS

In this study of QT prolongation taken into consideration the Q-T interval, we have used two sets of databases to assess the performance of the Algorithm. These Database sources were taken from the physio-bank database. These database were taken from these physio-bank databases are such as MIT-BIH arrhythmia database and Q-T database respectively. ECGs obtained from these database sources are sampled at a given frequency of 200Hz. These sampled data obtained from physio bank database are Known as digital ECG sample.

Digitized data obtained from the above database sources are used in the proposed algorithm for the analysis of ECGs QT time interval which in turn is used to detect QT interval in each beat of an ECG sample. This will provide us

idea about the Arrhythmia realated to QT prolongation known as QT syndrome.

The samples which were used in the proposed algorithm provides the reliable result for various number of samples which were tested. In order to find out the QT interval, first of all Q-point and T-end point were detected through the given algorithm.

A Total of almost 100 samples were used for the analysis purpose and tested with the proposed algorithm in order to detect the given algorithm to find out Q and T-end point which is further used to calculate QT interval.

The recordings were digitized at 360 samples per second per channel with 11-bit resolution over a 10 mV range.

**For the QT –database,** Over 100 fifteen-minute two- lead ECG recordings (many excerpted from other databases), with onset, peak, and end markers for P, QRS, T, and (where present) U waves of from 30 to 50 selected beats in each recording.

These above samples were analyzed and tested using the given algorithm in which almost 32samples from QT – database and 13 samples from MIT-BIH arrhythmia database were provided satisfactory results.

In these results, proper Q-point and T-end point were obtained with a lot more precision.

Through the analysis of these samples used for the experimental purpose from the given data base sources, we have obtained some false Q-point and T-end point in a particular beat associated with the given samples which is to be

analysed. These wrongly detected false Q-point and T-end point are properly explained in the given table of results. All the databases used in this experimental work is abnormal .

Following are the results which are obtained from the algorithm which is designed is given below,

It gives us the no of beats present in the particular sample,correctly detected and falsely detected Q-wave and T-end points in each beat of a sample which is analyzed.

**Table Results for MIT-BIH Arrhythmia Database**

<b>MIT-BIH ARRYTH.</b>	<b>Q -wave</b>			<b>T-wave</b>			<b>Test beats</b>
<b>MIT-BIH 100m.data</b>	<b>present</b>	<b>correct</b>	<b>false</b>	<b>present</b>	<b>correct</b>	<b>false</b>	<b>12</b>
<b>MIT-BIH 103m.data</b>	12	12	00	12	10	02	
<b>MIT-BIH 108m.data</b>	10	08	02	10	08	02	10
<b>MIT-BIH 114m.data</b>	09	09	00	09	09	00	09
<b>MIT-BIH 117m.data</b>	08	08	00	08	08	00	08
<b>MIT-BIH 122m.data</b>	08	05	03	08	07	01	08
	13	09	04	13	10	03	13

**Table 4.3 Results for QT DATABASE**

QT data base	Q -wave			T-wave			Test beats
	present	Correctly detected	Falsely detected	present	Correctly detected	Falsely detected	11
<b>Sel 103m</b>							11
	11	08	03	11	08	03	
<b>Sel 33m</b>	04	02	02	04	03	01	04
<b>Sel 36m</b>	09	07	02	09	05	04	09
<b>Sel 37m</b>	06	04	02	06	03	03	06
<b>Sel 46m</b>	10	09	01	10	05	05	10
<b>Sel 49m</b>	08	03	05	08	07	01	08
<b>Sel 51m</b>	08	05	03	08	07	01	08
<b>Sel 114m</b>	08	06	00	08	08	00	08

## **CONCLUSION**

From the above experimental work, it is concluded that in case of the uniform ECGs sample used from the different database sources, Q-point and T-end point are detected accurately for each of the beat in a particular sample which is to be analysed. But in the case of non-uniform ECGs i.e. drifting of ECGs base line or interference with the noise, the proposed algorithm is not been able to detect Q-point and T-end point for each of the present beat in the particular sample correctly.

The algorithm designed to obtain these Q-points and T-end points of a particular beat in a given sample which contains no. of beats is detected correctly in large no of cases. Almost 32 samples from QT databases and 13 samples from MIT-BIH arrhythmia database, these Q-point and T-end point were detected correctly with a lot more accuracy. Apart from these correctly detected samples, other sample which has been analysed by this algorithm does not provide desired result.

So for these samples which do not provide desired result, we need to further optimize our algorithm for the correct detection of these points. A proper optimization of the given Algorithm is required for the analysis of all other wrongly detected sample points of Q and T-end.

## FUTURE ASPECTS

**Algorithm is designed for only Q-point and T-end point in a particular beat of any given sample which is tested.**

**Thus by proper optimization of the proposed Algorithm, experimental work may be extended for the other wrongly detected Q and T-end point in other samples in order to find out QT interval.**

## REFERENCES

- [1]. L. Cromwell, F. Weibell, E. Pfeiffer, "Biomedical Instrumentation and Measurements", Prentice Hall, 1996. <https://pdfcoffee.com/biomedical-instrumentation-and-measurements-pdf-free.html>
- [2]. A. Guyton, J. Hall, "Textbook of Medical Physiology", Philadelphia: W.B. Saunders, c1996. <http://www.cvphysiology.com/Arrhythmias/A013.html>
- [3]. Q. Xue, S. Reddy, "Algorithms for Computerized QT Analysis", Journal of Electrocardiology, Vol. 30 Suppl.
- [4]. A. Hunt, "Accuracy of popular automatic QT interval algorithms assessed by 'Gold Standard' and comparison with novel method: computer simulation study", BMC Cardiovascular Disorders, September 2005.
- [5]. Q. Xue, S. Reddy, "New Algorithms for QT Dispersion Analysis", IEEE Computers in Cardiology, 1996. <https://ieeexplore.ieee.org/document/542531>
- [6]. P. Lanjewar, V. Pathak, Y. Lokhandwala, "Issues in QT interval Measurement", Indian Pacing and Electrophysiology Journal, vol. 4(4), 2004, pg. 156-161. <https://www.semanticscholar.org/paper/Issues-in-QT-interval-measurement-Lanjewar-Pathak/04e0a544d25f020c3c4de824e75ddda5edb94386>

- [7]. J. Sahambi, S.N. Tandon, R.K.P. Bhatt, "An Automated Approach to beat-by beat QT Interval Analysis", IEEE Engineering in Medicine and Biology, May/June, 2000, Pg. 97-101. <https://ieeexplore.ieee.org/document/844387>
- [8]. N. B. McLaughlin, R. Campbell, A. Murray, "Comparison of automatic QT measurement techniques in the normal 12 lead electrocardiogram", British Heart Journal, 74 Vol. 2, 1995, pg. 84-89. <https://www.hindawi.com/journals/crp/2010/961290/>
- [9]. P. Laguna, N.V. Thakor, P. Caminal, R. Jane, H. Yoon, "New algorithm for QT interval analysis in 24-hour Holter ECG: performance and applications", Medical & Biological Engineering & Computing, January 1990. <https://link.springer.com/article/10.1007/BF02441680>
- [10]. I.K. Daskalov, I.I. Christov, "Automatic detection of the electrocardiogram T-wave end", Medical & Biological Engineering & Computing, vol. 37, 1997. 64 <https://doczz.net/doc/4611111/28.01.2014---institute-of-biophysics-and-biomedical-engin...>
- [11]. R. Berger, "QT Variability", Journal of Electrocardiology, vol 36. Supplement, 2003. <https://www.ahajournals.org/doi/full/10.1161/01.cir.96.5.1557>
- [12]. J. Kautzner, "QT interval Measurements", Cardiac Electrophysiology Review. <https://link.springer.com/article/10.1023/A:1016389227576>
- [13]. A. Krahn, G. Klein, R. Yee, "Hysteresis of the RT Interval with Exercise: A new marker for Long-QTSyndrome?" Circulation, 1997;96:1551-1556. <https://www.ahajournals.org/doi/full/10.1161/CIRCEP.109.907865>
- [14]. V. Batchvarov et. al., "QT-RR relationship in healthy subjects exhibits substantial inter subject variability and high intrasubject stability", The American J Physiology Heart Circulation 282: H2356-H2363, 2002. <https://www.tga.gov.au/sites/default/files/auspar-levomilnacipran-161213-cer.docx>

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