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Signal Analysis of Electrocardiogram and Statistical Evaluation of Myocardial Enzyme in the Diagnosis and Treatment of Patients With Pneumonia

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ABSTRACT Pneumonia is a common disease in patients. This paper discusses the signal processing techniques of electrocardiogram (ECG) and the statistical analysis of myocardial enzymes in the diagnosis and treatment of patients with pneumonia and analyzes its significance. Detecting the activity of creatine kinase (CK), isoenzyme (CK-MB), and cardiac troponin T (CTnT) before and after treatment in patients with pneumonia and recording the changes of the electrocardiogram with non-invasive bedside conventional electrocardiogram can be useful for medical diagnosis. In addition, in order to eliminate the ECG signal noise to improve the accuracy of analysis and diagnosis, we have introduced a Butterworth filter to achieve the suppression of interference signals. Moreover, the Butterworth filter method is used to denoise the ECG signal, and the selection of wavelet function, the analysis of noise frequency band, and the threshold processing are solved accordingly. This method has the characteristics of simple calculation and fast processing speed. It can effectively suppress baseline drift noise and improve the overall operation speed. The experimental results show that the proposed method can well filter baseline drift, power frequency interference, EMG interference, and other high-frequency interference in ECG signals, and the real-time performance of the Butterworth filter method in the sampling process has good performance, which provides help for diagnosis. Via comparing and analyzing different ECG signal parameters between the groups, the serum levels of CK, CK-MB, and troponin are demonstrated to be significantly increased with the severity of the disease in patients with pneumonia. Abnormal changes in the ECG indicate that the myocardium may be affected after pneumonia in patients. The detection of CK-MB and troponin levels in the serum of patients with pneumonia has very high sensitivity and specificity. Recording electrocardiogram has good intuitive utility. ECG and myocardial enzyme monitoring are of great significance in the diagnosis and treatment of the development of the disease in patients with pneumonia.

INDEX TERMS Electrocardiogram signal, Butterworth filter, interference signal, pneumonia, myocardial enzyme.

I. INTRODUCTION

Cardiovascular system is the most easily implicated organ when patients suffer from respiratory disease, which can exhibit important signs [1]. Pneumonia is a respiratory disease that patients are prone to suffer from, it is a major threat to patients' health, and has the features of acute onset, quickly development and high mortality [2]. The respiratory and cardiovascular systems of patients cannot function independently. Patients are prone to lead to hypoxia and hypercapnia caused by hypoxia, even acidosis. If the heart is affected, it can cause myocardial damage [3]. Therefore, in addition to symptoms, the detection of serum myocardial enzymes with pneumonia and non-invasive routine electrocardiogram (ECG) in patients are very useful tests to reflect whether the myocardium is damaged in patients with

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pneumonia. The sensitivity and specificity of ECG are strong, which is often used to dynamic observation and understand the occurrence of myocardial damage in patients with pneumonia and evaluation of therapeutic effect [4]. Therefore, both the quantitative detection of myocardial enzymes level of serum and the recording technique of ECG in patients have been widely carried out and popularized in hospitals above county level as routine examination items [5]–[11].

However, the ECG signals are easy to be affected by instruments and human activities. There are several situations that interfere with ECG signals [12]–[18]. First, the baseline drift is usually caused by human respiration and myocardial excitation when the frequency is lower than 1 Hz. It is showing a slowly changing curve. The second is EMG interference, which is caused by the human muscle tremor; its frequency range is very wide, generally between 10 Hz and 3 kHz. It is showing an irregular rapid change waveform. Third is the power frequency interference, its frequency is fixed at 50 Hz, ECG signal interference has a great impact on ECG data analysis. In order to eliminate the interference in the main aspects of ECG signals and retain useful information, the smoothing filter method was used to decompose the original ECG signal into signals in different frequency ranges in this paper. The signal was reconstructed by Butterworth filter [19]. This method can eliminate the baseline drift of ECG signal and restrain power frequency interference and EMG interference.

136 patients with pneumonia were examined for myocardial enzymes and ECG. The ECG signals were optimized by Butterworth filter and the changes of the observed values before and after treatment were compared and analyzed.

II. DATA AND METHODS

A. GENERAL DATA

Diagnostic criteria is based on fever, cough, shortness of breath, dyspnea, and moist rates of lung fixation, combined with etiological tests and X-ray or CT scans to exclude other diseases that can cause abnormal myocardial enzymes [20]. Specific requirements are that patients with mild illness are selected mainly for respiratory symptoms, the main manifestations are fever, most of the irregular fever, cough, shortness of breath, cyanosis and lungs appear in moderate to fine moist sounds, no respiratory failure and other visceral damage or failure. The criterion for admission to the critical group is high fever, hypoxia, toxemia and acidosis in addition to respiratory symptoms. Moreover, it also includes the following symptoms, that is, serious systemic toxic symptoms, heart failure, respiratory failure, diffuse intravascular coagulation, hyperthermia or hypothermia, toxic encephalopathy and toxic bowel paralysis, liver and kidney function damage, and even life-threatening. There were 87 patients with mild pneumonia, 49 males and 38 females. There was no significant difference in general information between mild pneumonia group, severe group and control group ($P>0.05$).

B. THERAPEUTIC METHOD

According to the symptoms of pneumonia in patients, we can take reasonable comprehensive treatment measures, that is, to actively control infection, keep the respiratory tract unobstructed, correct hypoxia, nourish the myocardium, prevent and treat complications, and enhance the body's resistance to promote rehabilitation. Specific treatment measures are as follows: (1) General nursing and supportive therapy, as soon as possible to give oxygen therapy, pay attention to nutrition and water supply, maintain airway patency, timely removal of nasal secretions and respiratory tract sputum. (2) According to the age, severity of the disease, past drug use, reference material sensitivity test, selection of appropriate anti-infective drugs. Penicillin is the first choice for Gram-positive cocci infection. Ampicillin or aminoglycoside antibiotics are commonly used for Gram-negative bacilli infection. Haloperidazine penicillin and metronidazole are used for anaerobic pneumonia. (3) Symptomatic treatment includes antipyretic, sedative, anticonvulsant, expectorant, antitussive and antiasthmatic. (4) Nutritional myocardium, medication for myocardial injury.

C. TEST METHOD

All the patients in pneumonia group were taken 3 ml of fasting venous blood by vacuum non-anticoagulant blood collection in the morning after admission, on the morning of the 8th day of hospitalization and in the control group within 3 days of physical examination. The activity of myocardial enzymes (creatine kinase (CK) and creatine kinase isoenzyme (CK-MB)) was determined by automatic biochemical analyzer (HITACHI7600-010). The kit was produced by Zhejiang Eastern European Bioengineering Co., Ltd (Batch number of reagents: 20160605). Cardiac troponin T (CTnT) is determined by immunofluorescence assay and the kit was provided by Shanghai Roche Company (batch number: 20161423). Normal values of myocardial is as follows: CK: 24-195 U/L, CK-MB:0-25 U/L, CTnT: 0-0.10 μg/L.

Electrocardiogram examination: All subjects completed the ECG recording. According to the literature, all types of normal or abnormal ECG in patients are defined [25]. The results are analyzed retrospectively by cardiovascular specialists from the recorded ECG paper.

ECG signal is a component of vital sign signal parameters. It changes with the excitation of cardiomyocytes. Because of the disturbance of human movement and external contact, the internal organs of human body are affected, and the ECG signal is disturbed by noise, which brings difficulties to the follow-up research. Therefore, the problem of noise removal plays a very important role in the preprocessing of ECG signals. ECG signal contains rich low-frequency components; and baseline drift will mask useful information, seriously affecting the accuracy of QRS wave group detection, waveform recognition and disease diagnosis and evaluation. Therefore, how to remove the baseline drift noise becomes an important problem in ECG signal processing.

There are two kinds of digital filter methods to suppress power-frequency interference: The first method is using classical filter methods, such as smoothing filter or narrowband notch filter with fixed center frequency. The other method is using adaptive filter methods. Although the method of adaptive filter can track the offset of power frequency signal adaptively, it usually needs the reference input signal of power frequency interference to realize the adaptive adjustment of filter coefficients. This reference signal is usually introduced by the acquisition system, which is not easy to implement for the system. The Butterworth filter is a commonly used method in instrument, and its technology is mature and easy to implement. Because of its low cut-off frequency band, EMG interference and power frequency interference can be filtered, so the system uses Butterworth filter to suppress power frequency interference signal. The Butterworth filter method requires the original ECG signal to satisfy the following two conditions: Firstly, the sampling frequency F should be an integer multiple of the power frequency interference. Secondly, in a power frequency interference period T, the algebraic sum of the amplitudes of the power frequency interference sampling points is zero.

The Butterworth filter is characterized by the most flat frequency response curve in the pass band, no fluctuation, and in the stopband is gradually reduced to zero. The amplitude diagonal frequency of Butterworth filter decreases monotonously and the higher the order of the filter, the faster the amplitude attenuation speed in stopband. The higher order amplitude diagonal frequency map of other filters and the lower order amplitude diagonal frequency has different shapes.

In this paper, the low-pass filter is designed as a Butterworth filter by calculating coefficients a, b and c.

$$\frac{V_{out}}{V_{in}} = \frac{1}{a \cdot s^{2\alpha} + b \cdot s^{\alpha} + c} \tag{1}$$

The square of the amplitude-frequency characteristic function corresponding to the characteristic equation of formula (1) is:

$$|D(jw)|^2 = c^2 + a^2w^{4\alpha} + b^2w^{2\alpha} + 2abw^{3\alpha} \cdot \cos(0.5\alpha\pi) + 2acw^{2\alpha} \cdot \cos(\alpha\pi) + 2bcw^{\alpha} \cdot \cos(0.5\alpha\pi) \tag{2}$$

The square of the amplitude-frequency characteristic function corresponding to the characteristic equation of the transfer function of the ideal 2α-order Butterworth filter is:

$$|D(jw)|^2 = 1 + \varepsilon \cdot w^{4\alpha} \tag{3}$$

By contrast formula (2) and formula (3), make $c = 1$, $a^2 = \varepsilon$in formula (2), the sum of the first two terms formula (2) of formula (3) is the same. The remainder of formula (2) is defined as an error term, as shown in formula (4):

$$F(jw) = b^2w^{2\alpha} + 2abw^{3\alpha} \cdot \cos(0.5\alpha\pi) + 2acw^{2\alpha} \cdot \cos(\alpha\pi) + 2bcw^{\alpha} \cdot \cos(0.5\alpha\pi) \tag{4}$$

Obviously, the error term of the Butterworth filter is equal to 0 on the cut-off frequency w_0, as shown in equation (5):

$$b^2w_0^{2\alpha} + 2abw_0^{3\alpha} \cdot \cos(0.5\alpha\pi) + 2acw_0^{2\alpha} \cdot \cos(\alpha\pi) + 2bcw_0^{\alpha} \cdot \cos(0.5\alpha\pi) = 0 \tag{5}$$

According to the definition of formula (3) and cut-off frequency, the relationship between cut-off frequencyw_0 and coefficient ε can be obtained as follows:

$$\varepsilon \cdot w_0^{4\alpha} = 1 \tag{6}$$

The relationship between a and w_0 is also obtained from $\varepsilon = a^2$:

$$a = \frac{1}{w_0^{2\alpha}} \tag{7}$$

By formula (6) and (7), the equation (8) is established:

$$b^2w_0^{2\alpha} + 4bw_0^{\alpha} \cdot \cos(0.5\alpha\pi) + 2\cos(\alpha\pi) = 0 \tag{8}$$

Solution formula (8), the value of b is shown in equation (9):

$$b = \begin{cases} \dfrac{-2\cos(0.5\alpha\pi) + \sqrt{2}}{w_0^{\alpha}}, & 0.5 + 2k < \alpha \leq 1.5 + 2k \\ \dfrac{-2\cos(0.5\alpha\pi) \pm \sqrt{2}}{w_0^{\alpha}}, & 1.5 + 2k < \alpha \leq 2 + 2k \end{cases} \tag{9}$$

where k is a non-negative integer.

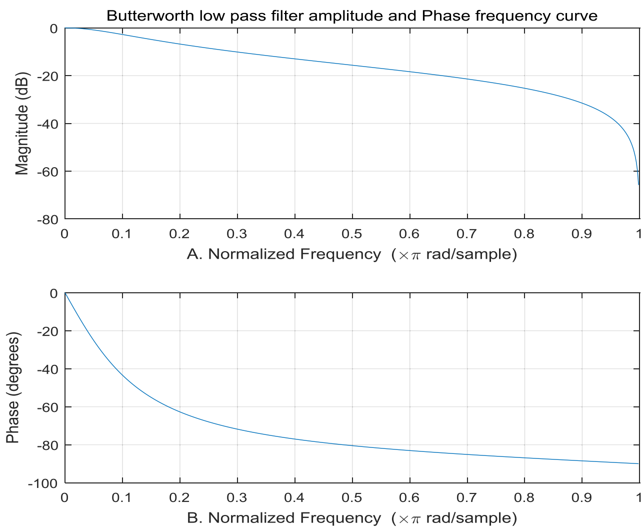

FIGURE 1. Butterworth low pass filter amplitude and Phase frequency curve.

Figure 1 is the amplitude-frequency response curve of the designed Butterworth digital low-pass filter. Figure 2 is the waveform diagram of ECG signal before and after filtering in time domain. It is obvious from the diagram that the myocardial signal is filtered and the power frequency interference is suppressed. Figure 3 is the spectrum diagram of ECG signal before and after filtering in frequency domain. Figure 4 is the power spectrum diagram of ECG signal.

Because the power supply network is ubiquitous, 50Hz power frequency interference is the most common, also the main source of ECG interference. The design methods of 50HZ notch filter are various. The common methods are wavelet transform filtering, adaptive filtering, template

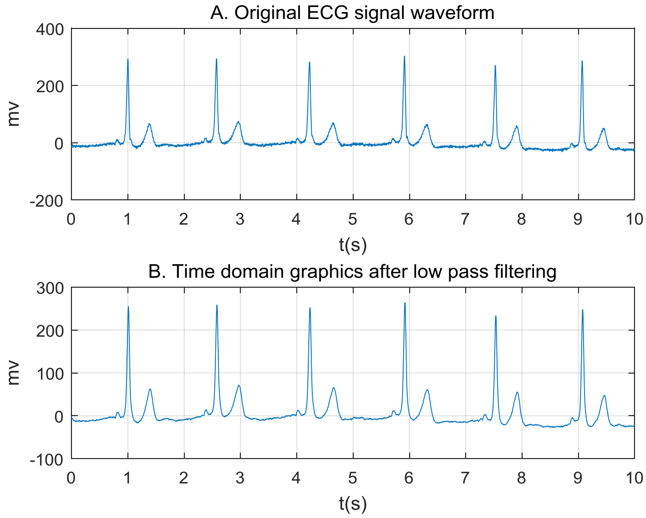

FIGURE 2. Original ECG signal and Butterworth low pass filter processed ECG signal.

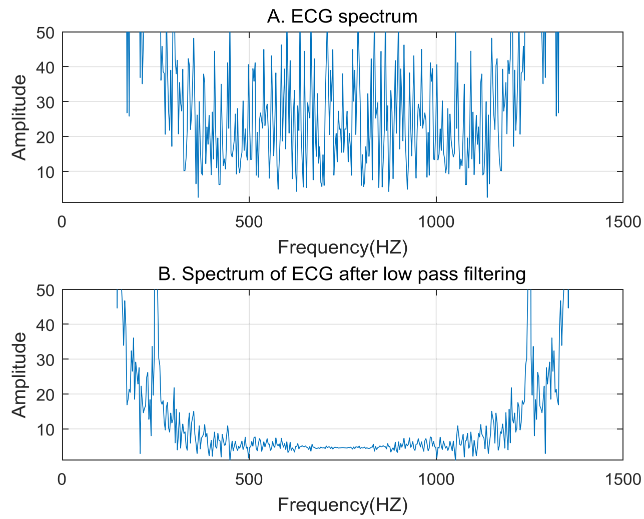

FIGURE 3. ECG signal spectrum.

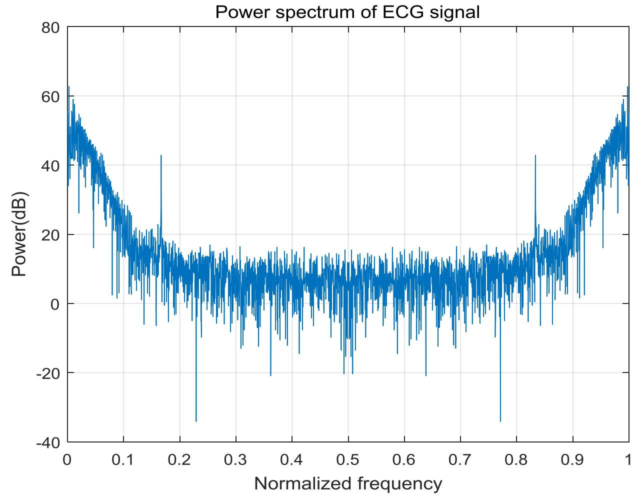

FIGURE 4. Power spectrum of ECG signal.

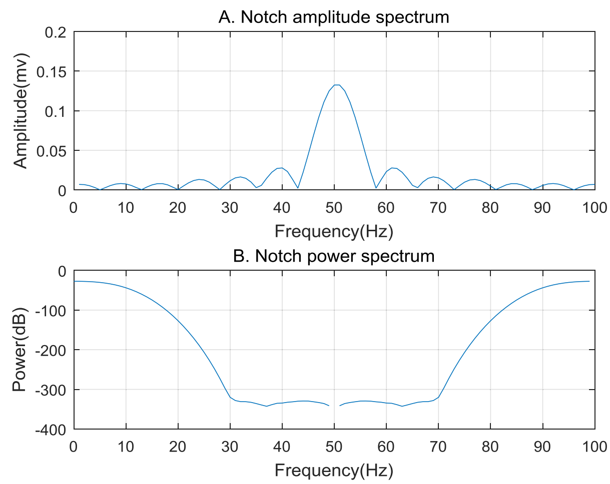

FIGURE 5. Notch amplitude and power spectrum of ECG signal.

matched filtering, etc. But the parameters of the filter need to be calculated manually, and the operation is complicated. In filter design, Infinite Impulse Response (IIR) filter can reduce the order and operation, but destroy the phase characteristics. Using FIR filter can not only get good filtering effect, but also achieve the lowest waveform distortion. Moreover, FIR filter can make linear phase characteristics, which is exactly the need for ECG signal filtering. The methods of designing FIR filter by MATLAB include window function method, frequency sampling method and Chebyshev approximation method. The 50HZ notch filter is designed by window function method. The basic idea of the window function method is to select a suitable ideal low pass filter according to the requirements. Because the impulse response is non-causal and infinitely long, the optimal window structure window function is used to intercept the impulse response, and the linear phase and causal FIR filter is obtained. Kaiser window is a window function approaching the optimal window structure. It can adjust the parameters of the filter according to different parameters. Therefore, the filter design using Kaiser window function can suppress power frequency interference. Figure 5 is the notch amplitude and power spectrum of ECG signal. Figure 6 is ECG band-stop filtered signal. As can be seen from Figure 6, this method can effectively suppress the power-frequency interference of ECG signal and provide effective help for medical services.

The ECG signal is a very weak signal. The suppression of the voice is the key to ECG signal detection. ECG signal contains abundant low-frequency parts, and baseline drift will affect its waveform, which masks some characteristic waveforms of ECG, thus increasing the difficulty of observation and analysis in subsequent processing steps such as QRS detection and recognition. Eliminating baseline drift of ECG is an important problem in ECG signal processing. When baseline drift is very serious, it is difficult to identify and measure waveforms. Sometimes it is even impossible

TABLE 1. Comparison of myocardial enzyme monitoring results between normal patients and pneumonia patients.

category	n	CK (U/L)		CK-MB (U/L)		CTnT (μg/L)	
		Before treatment	After Treatment	Before treatment	After treatment	Before treatment	After treatment
control group	68	159.11 +/- 29.84		20.07 +/- 11.25		0.07 +/- 0.01	
mild group	87	"239.54 +/- 67.02	"162.73 +/- 29.76	*39.74 +/- 29.47	"22.59 +/- 10.61	*0.21 +/- 0.28	"0.09 +/- 0.03
severe group	49	317.56 +/- 50.22	"173.33 +/- 31.25	**86.87 +/- 31.74	38.45 +/- 13.18	**0.96 +/- 0.47	†0.16 +/- 0.05

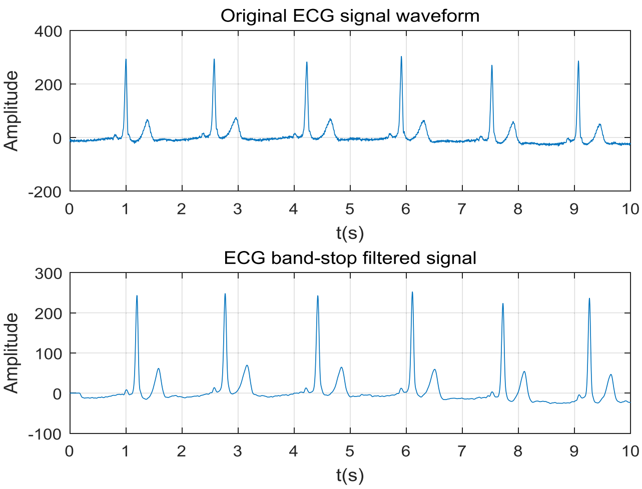

FIGURE 6. ECG band-stop filtered signal.

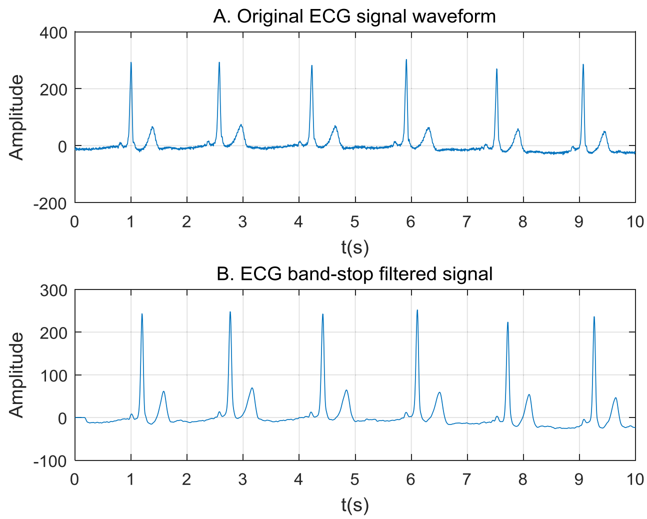

FIGURE 7. Filtered signal electrocardiogram before and after filtering in time domain.

to record. Baseline drift is caused by breathing, limb movement or exercise electrocardiogram test, which makes the baseline of ECG signal drift up and down. It is a slowly changing low-frequency signal, and can be used to correct baseline drift by curve fitting method. However, when ECG signal is weak, the difference point is difficult to extract. In order to eliminate the interference of tomb line drift, many methods have been proposed and applied at home and abroad. The two most commonly used methods are high-pass filter and wavelet transform to remove baseline drift. In this paper, zero phase shift filter is used to correct baseline drift, which is a signal sequence filtered by the filter without phase change. The phase response of the filter system function is zero. Obviously, it is impossible to achieve zero phase shift for causal system, and it is impossible to achieve zero phase shift without knowing the phase spectrum of the signal beforehand. Zero phase shift can only be applied to non causal systems. Specifically, zero-phase-shift filters use the information contained in the signal points before and after the current signal points, essentially using "future information" to eliminate phase distortion. Figure 7 is an electrocardiogram before and after filtering in time domain. It can be seen that the baseline drift is improved after filtering.

D. STATISTICAL PROCESSING

The data is analyzed by SPSS17.0 statistical software, and the measurement data is expressed as mean +/− standard deviation form. The comparison between groups is performed by one-way ANOVA and the pairwise comparison is performed by t-test. The χ^2 is used to compare the rates, and the difference is statistically significant in $P < 0.05$.

III. RESULT

A. CHANGES OF MYOCARDIAL ENZYMES BEFORE AND AFTER TREATMENT

As can be seen from Table 1, before treatment, CK level in the mild group increased compared with the control group, but there is no significant difference (P>0.05), the values of CK-MB and CTnT are significantly higher than those of the control group (P<0.05). In severe group, the levels of

TABLE 2. Abnormal ECG distribution in normal patients and patients with pneumonia.

ECG change	Control group (n = 68)	Mild group (n = 87)		Severe group (n = 49)	
		Before treatment	After treatment	Before treatment	After treatment
Sinus tachycardia	2	17	3	9	2
Sinus bradycardia	1	2	0	2	1
Paroxysmal supraventricular tachycardia	0	1	0	0	0
Bundle branch block	0	2	0	5	2
P wave height tip	0	0	1	6	1
Prolongation of P-R or QT interval	0	0	0	2	0
ST segment elevation or depression	0	2	1	3	1
flat or inversed T wave	0	0	0	2	1
Atrial premature beat	1	10	1	6	0
Ventricular premature beat	1	6	0	3	0
Ventricular tachycardia	0	0	0	1	1

CK, CK-MB and CTnT in serum are significantly higher than those in control group, and the levels of CK-MB and CTnT are also significantly higher than those in mild group ($P<0.01$). It means that both the disease and the contents of the serum enzyme level of patients with pneumonia increase. After treatment, the levels of CK, CK-MB and CTnT in the mild group return almost to normal level ($P>0.05$), CK level recovers obviously in the severe group, there are still significant differences in the levels of CK-MB and CTnT ($P<0.05$). However, the levels of CK, CK MB and CTnT are significantly lower than those of the same group before treatment ($P<0.01$), and compared with the mild group, there is no significant difference in the content after treatment ($P>0.05$). In the Table 1, compared with the control group, $^{*}P < 0.05$, $''P > 0.05$; compared with the mild group, $^{**}P < 0.01$; Compared with the same group before treatment, $\dagger P < 0.01$.

B. ECG CHANGES IN ADMISSION AND AFTER TREATMENT

The results of Table 2 and Figure 5 show that 40 cases (45.98%) have characteristic changes of ECG ($P<0.01$) before treatment in mild group, and sinus tachycardia and premature atrial beats are more common. Severe group has severe changes of ECG in 39 cases (79.59%) before treatment. There are much more severe ST segment changes and T wave abnormalities, P wave apex and bundle branch block besides common sinus tachycardia and atrial premature beats. (compared with the control group, $P < 0.01$; compared with mild group, $P < 0.05$). After treatment, the ECG of most pneumonia patients in the mild group returns to normal level (compared with the control group, $P>0.05$). The recovery of ECG characteristic changes in severe pneumonia patients is also obvious, severe ST segment and T wave are flat or elevated, ventricular tachycardia and bundle branch block are difficult to recover. More statistics shows that 9 cases with severe changes of ECG die (18.37%).

C. CHANGES OF MYOCARDIAL ENZYMES AND ECG AND THEIR RELATIONSHIP WITH DISEASE

Before treatment, CK-MB and CTnT in serum of patients with pneumonia in mild group are significantly increased. ECG is characterized by sinus tachycardia and ectopic rhythm. The prominent symptoms of the patients are fever, cough, shortness of breath, pulmonary hypertension, etc. After combined treatment, the patients' pneumonia can be cured. In severe group, the levels of CK, CK-MB and CTnT in serum of patients with pneumonia were not only higher than those of control group, but also significantly higher than those of mild group, especially the increased activities of CK-MB (4 times higher than that of control group) and CTnT (8 times higher than that of control group). ECG is characterized by almost all types of ECG abnormalities in patients, bundle branch block, ST-segment and T-wave changes, and ventricular tachycardia, which reflect worsening cardiac injury. The manifestations of patients with pneumonia include myocardial ischemia, myocarditis, heart failure, even sudden death, besides symptoms of mild group. Although most of the patients' symptoms are alleviated by active combined symptomatic treatment, the serum levels of CK-MB and CTnT in patients with pneumonia are significantly higher than those in the control group, and ECG still has the characteristics of myocardial injury.

IV. DISCUSSION

In signal processing, the ECG of the mild patients show the characteristics of heart rate acceleration, P wave sharp, ectopic rhythm when patients infected with pneumonia, and the ECG of the severe patients show ST-T segment changes, QT interval prolongation, electrical impulse conduction changes and ectopic rhythm. After active treatment, most of these symptoms are cured, patients with severe pneumonia may be difficult to cure in the short term, or even die. The results show that 45.98% of the patients in the mild group have ECG abnormalities, which are characterized by sinus tachycardia and atrial premature beats. The proportion of patients with pneumonia with abnormal ECG in severe group is 79.59%. ECG manifestation types almost covered all abnormal ECG features in patients. In addition to the characteristics of sinus tachycardia in the mild group, there are also significant changes in P wave height, bundle branch block, ST segment and T wave, which indicated that the severity of myocardial damage is obvious in the severe group. After treatment, the symptoms of patients with pneumonia in the mild group are cured, the symptoms of patients with pneumonia in the severe group are not improved, and especially those with bundle branch block and ST-T segment change. The results show that the myocardium of these patients with pneumonia is seriously damaged and the prognosis is not better. It is worthwhile to strengthen the dynamic ECG monitoring, adjust the dosage and type of drugs in time, treat symptoms and prevent accidents [21].

As many as 4 million patients worldwide die of pneumonia every year, the main reason is that pneumonia tends to cause hypoxia and heart failure in patients, especially in many developing countries [22]. Heart failure is a very important complication of pneumonia in patients. Because of the abundant enzymes in cardiomyocytes, the membrane of cardiomyocytes can act as a barrier under normal physiological conditions to prevent the overflow of enzymes, and make the activity of serum myocardial enzymes very low. Moreover, normal myocardial activity also leads to normal ECG exchange and conduction, ECG shows normal sinus heart rate. However, when patients are infected with viruses, bacteria, mycoplasma that will cause pulmonary infections and myocardial damage, the serum levels of key myocardial enzymes, such as CK, CK-MB and CTnT, increase abnormally. ECG recording shows specific changes, and these abnormalities are proportional to the degree of myocardial damage. Therefore, it can directly reflect the degree of myocardial damage in patients with pneumonia, and has high sensitivity, specificity and practicality [23].

Patients with pneumonia are more likely to suffer from increased oxygen free radicals and lipid peroxides in the body, insufficient tissue perfusion and accumulation of acidic substances, which directly damage the biofilm of myocardial cells and cause the release of myocardial enzymes into the blood. In this case, the speed and amount of enzymes released from cardiomyocytes into the blood is related to the degree of damage to the heart cells. The disease is more serious that will cause the more serious damage to the heart muscle and the higher the activity of serum cardiomyocytes [24], [25]. However, after combined symptomatic treatment, such as anti-infection, myocardial nutrition, free radical elimination and myocardial protection of drugs, the majority of patients with pneumonia myocardial enzymes can return to normal levels. The results show that before treatment, the serum levels of myocardial enzymes in patients with pneumonia are significantly higher than those in the control group. In the mild group, the levels of CK-MB and CTnT are significantly higher than those in the control group except slightly higher CK levels. In the severe group, the serum's CK, CK-MB and CTnT values of patients with pneumonia are not only higher than those of the control group, but also significantly higher than those of the mild group, especially the increase of CK-MB (4 times higher than that of the control group) and CTnT (almost 10 times higher than that of the control group). The results show that the level of serum enzymes in patients with pneumonia is significantly increased with the deepening of pneumonia, and the degree of myocardial damage is also aggravated. Only CK-MB and CTnT increase significantly in mild group, reflecting the sensitivity of CK-MB and CTnT. In severe group, the levels of CK-MB and CTnT increase several times, reflecting the specificity of CK-MB and CTnT [26]. After active combined treatment, the CK, CK MB and CTnT values of the mild group decrease significantly. The CK level returns to normal range, the CK-MB and CTnT values in the severe group are still different from those in the control group. It shows that the severity of myocardial injury in patients with severe pneumonia is demonstrated. This may be related to the serious myocardial injury in the individual cases in this group, which cannot be cured in the course of treatment until death.

Finally, this study explores the effects of myocardial enzymes and ECG on patients with pneumonia and their relationship. The results show that the serum CK removal in patients with pneumonia in mild group increases slightly before treatment. The levels of CK-MB and CTnT are significantly higher than those in the control group. ECG is characterized by sinus tachycardia and heterotropic rhythm. The symptoms are fever, cough, shortness of breath and pulmonary hypertension. It is suggested that the increased levels of CK-MB, CTnT and abnormal ECG may be a stress response. The heart is only in a state of compensatory involvement and treated with combined anti-infection therapy. The above laboratory test indicators and bedside ECG test can be restored to normal, without sequela. The serum levels of CK, CK-MB and CTnT in severe group are not only higher than those in control group, but also significantly higher than those in mild group, especially the increased activity of CK-MB and CTnT. The characteristics of ECG are almost related to the whole features of ECG abnormalities in patients, and there are bundle branch block, ST-segment and T-wave changes and ventricular tachycardia which reflect the aggravation of cardiac injury. Symptoms of patients with pneumonia include myocardial ischemia, myocarditis, heart failure, and even sudden death. It shows that severe patients are developing pneumonia, which may involve the myocardial tissue and lead to organic changes in the heart. Although most of the patients' symptoms are alleviated by active combined symptomatic treatment, the serum levels of CK-MB and CTnT in patients with pneumonia are significantly higher than those in the control group, and ECG still has myocardial injury characteristics. This particular phenomenon may be related to the death of 9 patients with pneumonia during the diagnosis and treatment. In these 9 deaths, the CK-MB and CTnT levels at admission are significantly higher than the average in this group. ECG is characterized by ST-T segment changes, bundle branch block and ventricular arrhythmias. In the course of treatment, the observation items are increased significantly. Therefore, for the treatment of patients with severe pneumonia, we need to emphasize joint and positive long-term treatment, especially for special individualized treatment to prevent death, such as intravenous gamma globulin [27].

V. CONCLUSION

In this paper, we have implemented the Butterworth filter to process ECG signals of patients. Bedside non-invasive ECG detection is more simple, intuitive and economical. The results of ECG signal processing show that this method can effectively suppress baseline drift voice without distortion of ECG signal. Those methods can reflect the status of myocardial damage in patients with pneumonia. Detection of the CK-MB and CTnT levels in patients with pneumonia has better sensitivity and specificity. The diagnosis, treatment and prognosis of pneumonia can complement one another; and have very important value and guiding significance.

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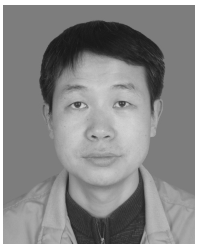

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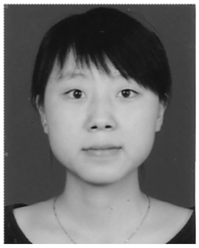

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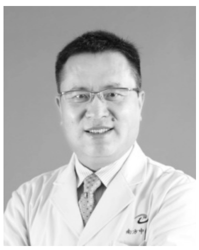

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