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Using Autoregressive Spectral Analysis to Investigate Weaning Index

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Abstract-**Mechanical ventilation is widely used in lifesaving. But it will be associated with numerous complications. Patients of weaning failure are about 7% to 19% and are subjected to high mortality [1]. To investigate this problem, we use digital signal process approach.**

We record breathing data before and after weaning. The patients' weaning success and weaning failure are also recorded. Autoregressive Power Spectral Density method is used to quantify the breathing data and investigate its rhythm changes. From spectral analysis, the power ratio of the first two peaks in the low frequency regions is calculated. We observed that patients with weaning failure have this ratio less than 1.This ratio may be a good weaning index.

Keywords - **digital signal process approach, Autoregressive Power Spectral Density, rhythm changes, weaning index**

I. INTRODUCTION

Recently, mechanical ventilation is widely used in lifesaving. But it will be associated with numerous complications. The usage time should be short and discontinue as early as possible. Many weaning indices, such as breathing pattern, arterial blood gas and lung mechanisms have been developed to help predict the successful discontinuation of mechanical ventilator. However, determination of the optional time to discontinues ventilator support can be very difficult. Patients of weaning failure are about 7% to 19% and are subjected to high mortality [1].

Analyzing breathing pattern can provide valuable information about respiratory system. Patients with intact respiratory center (preserved brain stem function) are most closely associated to patients stress and physiologic condition. Common weaning parameters are frequency, tidal volume, and rapid shallow breathing index, and inspiratory time. Patients who failed a weaning trail had considerable breath-to-breath variation in relative contribution of the rib cage and abdomen to tidal volume [2].

The classic methods for analyzing breathing pattern all focused on single or mean value. No attention is pay to the rhythm change. Series data may give more information than spot data.In this paper, spectral analysis is used to study the breathing pattern rhythm change before and after weaning and quantify it. The power ratio of the first two peaks in the low frequency regions is calculated. We find that this ratio is a good potential for using a weaning index.

II. METHODOLOGY

Six patients, who is mechanically ventilated for more than 24 hours in Intensive Care Unit are selected for weaning. After general care and sputum suction, a fixed orifice flow sensor is connected into endotracheal tube orifice. The signals of flow are collected by Ventrak® respiratory monitor with sample rate of 100 Hz. The patient breathes from T-tube with FiO2 5% higher than the ventilator setting. The signal is collected at least 5 min after 30 minutes of T-tube trial. No therapy or physical interruption is allowed in this period. The patient's status is all recorded. The failure of weaning is defined as intubation or reuse of mechanical ventilator within 48 hours of weaning. The usage of noninvasive ventilator is not regarded as weaning failure. The spectral analysis structure is shown in fig.1.

Once inspiratory time is obtained, the breath-by-breath base variable includes mean and standard deviation will be also calculated. In frequency domain, inspiratory time is plotted into tachogram(fig.2). Tachogram means ranking inspiratory time readings according to time series. Then, modified covariance method is used to evaluate the autoregressive coefficients. In autoregressive model, order selection is an important task. We use Akaike Information Criterion to calculate the order for each case. The average of these cases is used as the autoregressive model order. Autoregressive Power Spectral Density will be calculated based on these autoregressive coefficients and order 14. Moreover, the power ratio of the first two peaks in low frequency regions is calculated.[3] .

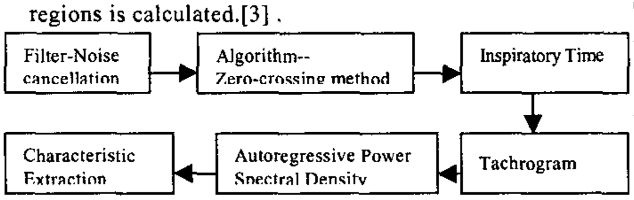

Fig 1 spectral analysis structure

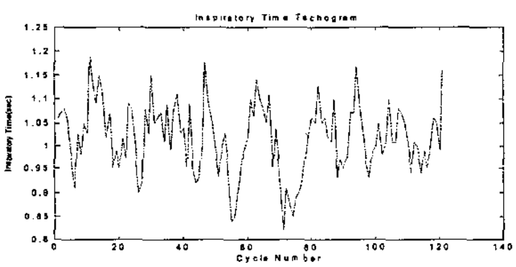

Fig2. Tachogram

III. RESULTS

In time domain analysis of inspiratory time, there is no significant difference found in its mean value and standard deviation value.

In frequency domain analysis, Table I is the peak power ratio of inspiratory amplitude between before and after weaning. Table II is peak power ratio of inspiratory amplitude between weaning success group and weaning failure group. We observed that the ratio of each patient in success group is greater than 1.

TABLE I

Peak Power Ratio of Inspiratory Amplitude between before and after weaning

Patients'ID	1	2	3	4	5	6
Before Weaning	1.150	1.80	0.926	1.690	1.730	6.150
After Weaning	0.797	0.659	0.967	1.510	1.450	2.900

TABLE II

Peak Power Ratio of Inspiratory Amplitude after weaning

Patients' Number	1	2	3
Weaning Success	1.510	1.450	2.90
Weaning Failure	0.797	0.659	0.967

IV. DISCUSSION

The normalized frequency of the first peak is always located in 0.1263±0.0376 (normalized Hz), and the normalized frequency of the second peak is always located in0.2279±0.0486 (normalized Hz). Like Heart Rate Variability[3], breathing is regulated by two types of cells. These two peaks may represent the effect of these groups of cells.

V. CONCLUSION

We find the weaning failure data may have the tendency to less than 1 in the first two peaks power ratio of the low frequency regions. This may due to oxygen - inhaled decreases in weaning failure patients. From spectrum analysis, we can observe that this ratio may be a good weaning index.

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