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Harmonic Variations of Arterial Pulse during Dying Process of Rats

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Abstract-**"Death" is often the largest issue people must face, but it is even more so in the medical field. Accurate forecasting of death not only has positive significance in treatment but also great help the doctor-patient relationship and the economics of medical treatment. However, accurate forecasting is not easy, so many studies to generate forecasting systems have been conducted.**

In this experiment, a fatal dose anesthetics, urethane, was injected into the abdomen of rats. Blood pressure waves in the rats' caudate arteries were then recorded during the dying process, and an analysis was conducted on the harmonics of the Fourier's transform obtained.

Of the 24 rats used in the experiment, 18 died and 6 survived. When a Kappa test was performed on the coefficient variation of the fourth harmonic magnitude(C.V.4) for the two groups of rats, it was found that when C.V.4 exceeded 1.7, the Kappa value was 0.75. This shows that during the death process the coefficience variation of the fourth harmonic magnitude clearly increases.

I. INTRODUCTION

In both philosophy and medicine, "death" is a major issue. The questions, "Will this person die?" and "When will this person die?" are some of the most difficult questions doctors might face. "Sudden death" is an even worse nightmare for doctors. However, these unavoidable problems and risks must be seriously addressed in intensive care wards, with anesthetized patients undergoing surgery, with end-stage cancer patients in hospices, and so on. Because these questions affect the course of treatment as well as the patients' families, there are broader implications in terms of medical economics and society [1, 2].

Nevertheless, accurate forecasting of death is not an easy matter, so many studies to generate forecasting systems have been conducted. These include assessment of patient condition near death [2-5], APACHE scores, SAPS scores [1], MPM scores [1, 6], PPI scores [7], even the use of neural networks to assist forecasting [8]. However, because most of these forecasting systems are qualitative, there are differences in accuracy, limits due to discipline, or variance due to ethnic differences [9-10]. Thus, to establish broad, accurate forecasting of death, an objective quantitative indicator may be needed.

Blood pressure, pulse, blood oxygen levels, body temperature, and breath rate are frequently-used physiological quantitative indicators, but these cannot provide enough information because they are usually kept within "living range" due to the intervention of treatment. Thus, analyzing these quantitative indicators has become a new direction of research [11-12].

Since death is caused by the failure of one or several organ systems, could the failure or death of these organs be revealed through blood pressure waves? The "Radial Coupled Resonance Theory" provided a positive connection: several experiments [13-17] have shown the effect that different organs have on various blood pressure harmonic wave effects. We can thus infer that the failure of various organs in the death process can also be expressed through variations in the various harmonics of blood pressure waves. The object of this study is to verify this hypothesis.

II. METHODOLOGY

Sprague Dawley rats weighing 300 to 350 g anesthetized with Urethane (1.2 mg/g body weight). The caudate arteries were cannulated via a 3/4 inch(No.25G) I.V. catheter. Blood pressure signals were recorded through a P10 EZ pressure gauge. The system's tested level frequency response could reach 60 Hz, and the signal, after amplification through a Gould amplifier and processing through an A-D converter, was input into an IBM PC for analysis [15-17].

After each rat was anesthetized, pressure wave readings were taken once per minute. Each data contented 7-10 blood pressure pulses. After Fourier's transform, the magnitude of the blood pressure pulses were averaged. The coefficience variation was calculated by standard variation divided average mean. Until the blood pressure waves had stabilized for 30 minutes, then the fatal dose of urethane was injected into the rats' abdomens.

The validity of forecasting was analysis by Kappa value(k) and X^2-test.

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k Actual Agreement beyond chance/ Potential Agreement beyond chance

When k=0-0.2:slight agreement; 0.2-0.4:fair;0.4-0.6:moderate;0.6-0.8: substantial; 0.8-1.0: almost

In the X^2-test: $X^2 = \sum [(O-E)^2/E]$, where O is the observed value; E the expected value. From the X^2 value, we could find out the p value, the chance of non-correlation[18,19].

III. Results

Of the 24 rats used in this experiment, 18 died and 6 survived. Fourier analysis conducted on the various wave harmonics showed that the maximal coefficience variations of the fourth harmonic magnitude of the 18 rats that died were (9.39 ± 2.76) higher than that of the 6 rats that survived (1.43 ± 0.47).

When a Kappa test was performed on the coefficience variation of the fourth harmonic magnitude(C.V.4) for the two groups of rats, it was found that when the C.V.4 exceeded 1.7, the Kappa value was 0.75 (Table 1).

We also use X^2-test by $X^2 = \sum [(O-E)^2/E]$. In this study $X^2 = 14.40$ which means $P < 0.001$.

TABLE I

KAPPA TEST VALUE OF COEFFICIENCE VARIATION OF THE FOURTH HARMONIC MAGNITUDE

	RATS		
	DIE	LIVING	
C.V. 4>1.7	18 (15)	2 (5)	20
C.V. 4<1.7	0 (3)	4 (1)	4
TOTAL	18	6	24

The mumbers in parenthese ( ) are the expected value
Observed agreement , accuracy rate = 0.92
Agreement expected on the basis of chance = 0.67
Kappa value =0.75

IV. Discussion

During the dying process of the rats, the coefficience variation of the fourth harmonic magnitude clearly increased, and as death approached, the variation became more evident. This phenomenon verifies a hypothesis derived from the "Radial Coupled Resonance Theory" and related experiments [13-17]: that the failure of various organs during the death process will be expressed through changes in the harmonics of blood pressure waves. Therefore, analysis of these wave harmonics may be used as a quantitative indicator that reflects physiological changes during the dying process.

In clinical practice, systolic and diastolic blood pressure are important physiological indicators, and a drop in blood pressure is viewed as an important danger sign. However, due to the intervention of treatment, these indicators are usually kept within "living range." In this experiment, the rats' dying process was also accompanied by a drop in blood pressure, especially when the diastolic blood pressure was lower than 40 mmHg, but this phenomenon did not indicate that death was inevitable. In the experiment, if the coefficience variation of the fourth harmonic magnitude of blood pressure waves did not show a clear increase, the drop in blood pressure could often stabilize on its own and even rise again. However, when the coefficience variation of the fourth harmonic magnitude showed a clear increase, then the drop in blood pressure became irreversible, and of course death would occur. Therefore, analysis of the harmonics of blood pressure waves provides a more accurate reflection of the dying process than traditional systolic and diastolic blood pressure measurement.

Therefore, by analysis of blood pressure wave harmonics, we can find a quantitative indicator that can be used for the development of a non-invasive means to provide instant and accurate forecasts or advance warnings of death.

Since this experiment was conducted on rats, further studies need to be conducted on other animal species or using other death-causing factors. The importance of various wave harmonics also awaits further analysis, before a broad, accurate, objective indicator to forecast death can be expected.

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