

公益財団法人 在宅医療助成 勇美記念財団

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仮設住宅における在宅医療を、中核病院にシームレス
につなぐ IT 電子診療システム

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Summary

In March 11, 2011, worst disaster called Sendai Quake attacked the north east side of Japan. In the disaster area, Tsunami removed the all building, so, we need simple and easy medical equipment. As the portable device, Electric doctor bag has been invented. In the traditional and alternative medicine, a pulse diagnosis is one of the most important diagnostic methods. However, there was no paper in which the medical evidence of a pulse diagnosis was shown. We invented the quantitative diagnosis machine which could carry out a pulse diagnosis scientifically. This machine could perform a pulse diagnosis using three pressure sensors. The pulse diagnosis is reproduced by various pressures being applied to three pressure sensors from external surface. Three experimental series including the experiments using model circulation circuit, an animal experimental series, and a clinical application with pulse diagnosis machine were conducted. Chaos theory was used for the evaluation in the clinical application of the pulse diagnosis machine. At least as for the part, the data which are in agreement with a traditional Chinese medicine by this pulse diagnosis machine are obtained. A part of Chinese medicine may have the scientific basis medically, in future. Scientific evidence may be able to be given to a pulse diagnosis for the first time in the world using invention of this pulse diagnosis machine.

Keywords—Sendai quake (Great East Japan Earthquake) Pulse diagnosis machine, Chinese medicine, Model circulation, pressure sensor

I. INTRODUCTION

In March 11, 2011, worst disaster called Sendai Quake (wiki) attacked the north east side of Japan. Magnitude 9.0 was the largest earthquake in the history of Japan. In the disaster area, especially in the east end of Japan, the Tsunami removed the all building. All hospitals and clinics were severely damaged.

Firstly, DMAT (Disaster Medical Association Team) had visited the Tsunami and earthquake area. Over thousands of teams went northeast side of Japan. It was so helpful, but information was so limited that it was very difficult to supply medical resource effectively. Every kinds of information tools were severely damaged, so no one knew who was survive

Secondly, anti-nuclear power activists send the malignant rumor concerning the Fukushima power plant meltdown. Anti nuclear power activists blocked the medical resource supply to the disaster area. So, shortage of medical equipment and drugs induced the cardiovascular events in the disaster



Fig.1 A photograph of a Miyazaki City after Tsunami attack. Almost all building had lost

So, we need simple and easy medical equipment. As the portable device, Electric doctor bag has been invented for the people in the Tsunami area.

Information had been so limited. No one had known the survival or not. Doctors, Nurses, and the Medical resource had

been severely limited. Life line had been severely damaged in the Tsunami area. Internet was broken. But, social network information and the Skype information had been useful for the refuge space, when the Internet information could be used.



Fig.2 A Photograph of a Refuge Canter after the disaster

To prevent the cardiovascular events in disaster area, tele-medicine and remote medicine should be useful because the medical resource in Tsunami area was so limited.

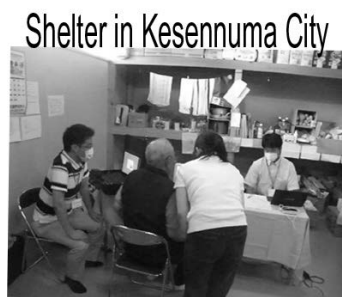


Fig.3 Tele-medicine between the Tsunami shelter and University

After the ethical committee allowance, clinical application of the tele-medicine system had been started between the tsunami damaged town and the University

In this paper, telemedicine using the electronic doctor's bag was reported and the pulse diagnosis machine in this system was reported and discussed.

II. TELEMEDICINE AND THE PULSE DIAGNOSIS

All medical resource had been very few, because the disaster was too large. Medical treatment had been limited, because all lifeline had been limited. For the people in the shelter, doctors with nurses had visited by themselves through destroyed roads.

We should consider the medical treatment under the condition of limited life line.

Electric doctor's bag had been invented in Tohoku University.



Fig.4 An electronic doctor's bag

Clinical application was started in the shelter in Kesenuma city, where was one of the most severe damaged

city with Tsunami, after the ethical committee allowance of the Tohoku University Graduate School of Medicine.

By the use of electronic Doctor's bag, Patient's condition could be able to be evaluated, though the doctors were located in University in Sendai. At the time of Disaster, number of doctor or nurse is too small. So, telemedicine or remote medicine is important. In the Electric doctor's bag, electrocardiogram, blood pressure measurements, and Ultrasonic diagnosis machine had been included. By the use of this newly developed system, people in the shelter had been able to talk with Doctor in the Tohoku University by Skype.

Various kinds of medical diagnosis machine can be included in the Electric doctor's bag. So, the Pulse diagnosis in the conventional and alternative medicine had been paid attention, because conventional diagnosis was non-invasive.

Before performing pulse-diagnosis machine development, the meaning which an arterial pulse wave form has was reconfirmed. Various kinds of information in the human body are theoretically included in the pressure wave form of an artery. Therefore, theoretically, various kinds of quantitative diagnosis will be embodied from this wave form. The rise foot of an artery wave is generated after ECG Q wave about 100ms. It is known medically that this standup delay time will be applicable also as an index of the cardiac function. When the heart contracts, an aortic valve will open, and blood will flow into an ascending Aorta from the left ventricle. Inter Aortic pressure will go up quickly simultaneously with blood inflow, and a pressure wave form will be formed. Therefore, the important information about a cardiac function is included in a rise foot.

It is the wave of the first peak in an artery pressure waveform, and Percussion wave in the first half of two waves near the pulse-wave peak, and they are mostly in agreement with the peak of a blood-flow wave. Although this wave is the

highest score in a youth healthy person, the Tidal wave generated next becomes the highest score in elderly people and an atherosclerosis patient. Tidal wave (recoil wave) is called Second wave, Catacrotic wave, Elastic wave, Spatsystolisher Gipfel, etc. Main components are the reflected waves from a peripheral, and have a shallow valley (Midsystolic dip) between Percussion wave in many cases. This wave is small at a youth and increases by atherosclerosis progress, such as an aging and a blood-pressure rise. Moreover, it becomes small as a pulse wave proceeds in a peripheral artery

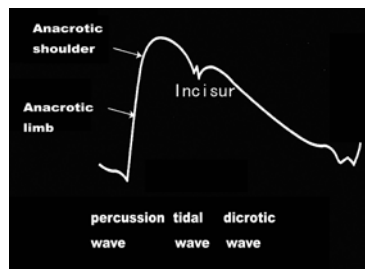


Fig. 6. Time series data of the Arterial pulse pressure waveform

As for Tidal wave, the Idiopathic Hypertrophic Subaortic Stenosis (IHSS), and aortic valve stenosis significantly influenced the waveform. The contraction dynamic state and the left ventricle outflow way are also participating in this wave formation..

The difference of the height of Percussion wave and Tidal wave and the ratio of full wave quantity are displayed in Augmentation Index $AI = \Delta p/A$. This is broadly applied as a parameter which shows the elastic modulus of a blood vessel system. Commercialization is also tried as an index called blood vessel age.

Formation of a notch is accepted in the downward foot of a main artery pressure waveform, and it is called the Incisor, dicrotic notch, etc. This is small vibration produced in a pulse

wave simultaneously with closing of an aortic valve. This is a cut which is between a contraction phase and a diastolic phase. Since it is the index which shows closing of an aortic valve, there is a report of disappearing by aortic valve closing insufficiency (AR). By the aging and blood-pressure rise, when main artery compliance becomes small, there is a tendency to decrease.

The upheaval which appears at an extended early stage is called Dicrotic wave, and originates in reflection from the peripheral of an artery pulse wave. Generally Tidal wave and dicrotic wave are reverse-correlated. In a youth, Dicrotic wave is large. In arteriosclerosis with an early advance of a reflected wave, Tidal wave becomes large. This Dicrotic wave is important in order to maintain a coronary-arteries blood flow. The artery pressure waveform to which this wave becomes large is called Dicrotic Pulse. For example, in DCM, Tidal wave disappears and turns into only Dicrotic wave. On the contrary, in aortic valve closing insufficient AR, Dicrotic wave falls prominent.

The elasticity of such an artery is fluctuated in response to change of not only an atherosclerosis but an autonomic-nerves tonus. Therefore, in the wave of a pulse wave, the control factor of a central nervous system also becomes an important parameter. Furthermore, if the amount of circulation blood increases, theoretically, it will work in the tendency for the whole pressure-waveform time series curve to go up. Moreover, if blood viscosity changes, it will result in affecting the whole waveform. Thus, various parameters worked mutually and have formed the waveform of a pulse wave.

So, it becomes possible to diagnose medical information from the wave form of the arterial pulse wave.

III. DEVELOPMENT AND A BASIC EXAMINATION OF A "PULSE-DIAGNOSIS MACHINE"

The pulse diagnosis in an Oriental Medicine contacts three fingers to the radius artery of both wrists. And it is carried out by carrying out a sensing pressing with a finger using various pressure. Therefore, it may be able to be embodied by applying theoretically three precise pressure sensors which Fig. 7 is shown.



Fig.7. Sensors for the Pulse diagnosis machine

If this machine is used, the embodiment of an objective and high scientific quantitative diagnosis of Pulse diagnosis with reproducibility is expectable. Then, the pressure sensor was contacted noninvasively from the radius artery skin surface based on the methodology of a pulse diagnosis so that it might show Figs. 7 and 8.

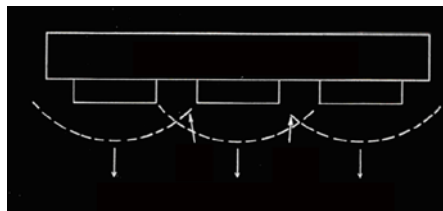


Fig.8 Concept diagram of three pressure sensors and Pulse diagnosis

The whole sensor was pressed in the direction of a perpendicular from external surface by the air pressure in which the quantitative evaluation is possible. The system which digitizes the sensing pressure waveform of the pulse diagnosis in an Oriental Medicine, and records on a data recorder was developed using this method. Pressure information is detectable with the pressure transfer on the upper surface of a radius artery so that it may show Fig. 8. It is perfect to carry out, after checking the basic performance in the model circulation circuit and checking safety, validity, etc. by the animal experiment in the system development.

It is considered to be standard after a check to perform clinical application at the last. Then, the model circulation circuit by the Wind Kessel theory of the left-heart circulation equipped with pre load, after load, and compliance was created using the artificial heart, and the basic performance was checked. The photograph of the pulse-diagnosis sensor with which the Moc circulation circuit which imitated the left-heart circulatory system was equipped is shown to Fig. 9.



Fig.9 A photograph of the pressure sensors for Pulse diagnosis and model circulation of a radial artery

Creation of the model circulation by the circulation medium which imitated blood in the model circulation circuit using an artificial heart was tried. The sensing by the pulse-diagnosis sensor was carried out to the model artery of various elastics

modulus which imitated the radius artery. Pressure by various air pressure induce was applied from sensor external surface, and reappearance of the scientific and quantitative pulse diagnosis using the pulse diagnosis of an Oriental Medicine was tried.

According to methodology with the reproducibility using such model circulation, the check of a measurement result which was good at scientific quantitative evaluation is attained.

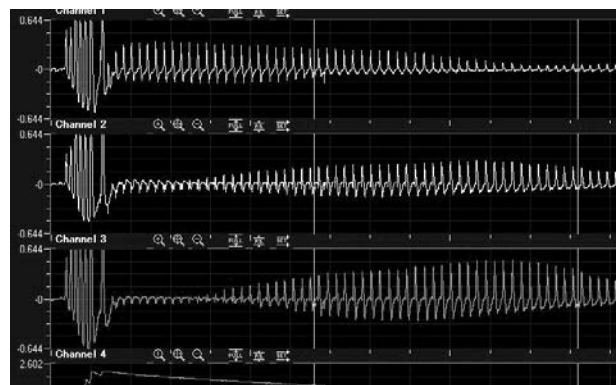


Fig.10 Alteration of an external surface pressures and pulse diagnosis sensor waveform. From upper tracing, waveform of the sensors of proximal, mid, and peripheral were shown.

If model circulation is used, it is easy to change the contractility of left-heart circulation independently. It may be able to be also simple in changing peripheral blood vessel resistance. Moreover, we can also free in changing compliance. Therefore, the factor of a pulse diagnosis can be evaluated quantitatively in Moc circuit.

The sensing result of the pulse diagnosis at the time of decreasing outside pressure gradually is shown to Fig. 10. Sequentially from the upper side, proximal side, mid side, and peripheral pulse wave were shown.

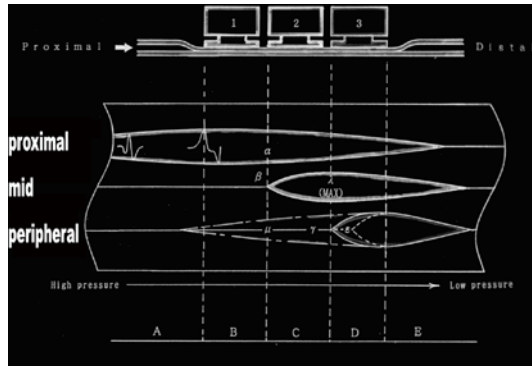


Fig.11 Theoretical background of the three pressure sensors waveform were shown

If it presses from external surface by high pressure and a radius artery is made to blockade by external pressure, pressure is undetectable in peripheral sides. On the other hand, if external pressure is loosened gradually, a gradually big sensing wave will be detected a central-site and peripheral side.

A theoretical background is shown to Fig. 11. It is thought that the measurement result of having been good quantity has presented the height of the probability of scientific measurement like a theoretical background. It becomes indispensable experimenting after the scientific probate examination of a model circulation circuit according to a living body. Then, the quantitative examination of the pulse-diagnosis machine using the goat holding the almost same weight as Japanese people was tried.

Using the goat with a weight of about 60kg, the neck was cut open, the carotid artery was exposed, the sensor was contacted, and the pulse-wave sensing examination was tried.

Consequently, the almost same pulse-diagnosis measurement result as Moc circulation was obtained, and detection of the wave-like change by medication was also embodied as the still more interesting data. In an animal experiment, it is also possible to fluctuate the object for the strange laborious works of the heart, the compliance of a blood vessel, peripheral

resistance, the amount of circulation blood, pre load, after load, etc. free unlike a human body.

Therefore, the quantitative experiment which can give a scientific basis can also be conducted to the concept of the Oriental Medicine in wave diagnosis of a pulse diagnosis from ancient times.

If this machine is used, the light of objective science can be applied to the world of an Oriental Medicine for the first time in the world.

Thus, first, the basic examination using Moc circuit was performed and the animal experiment was presented after that. After also fully checking safety, fixed quantity nature, and validity, finally the clinical test was tried.

IV. PULSE WAVE DIAGNOSIS IN ELECTRONIC DOCTOR'S BAG

In the area of disaster, simple and easy diagnosis method is needed. The diagnostic method of the pulse diagnosis in an Oriental Medicine may be useful if consideration is added theoretically, because is simple and easy. However, the paper which clarified the basis in scientifically and quantitatively does not exist until now, though regrettable. Only by the methodology of the pulse diagnosis of an old tradition, it must be said that there is no medical scientific evidence.

The reproducible method was aimed in order to apply a scientific light to the methodology of a pulse diagnosis in this study. The "pulse-diagnosis machine" in which quantitative measurement is possible was developed, and the elucidation of the medical scientific basis which the methodology of a pulse diagnosis had was tried.

Therefore, the Model circulation experiments were conducted, first. In a model, the contraction power of the heart, peripheral blood vessel resistance, arterial compliance, the pre load of the

heart, and after load could be changed quantitatively. A reproducible experiment can be conducted in a model. The side pressure applied to a radius artery by the pulse diagnosis and quantitative reappearance of a measurement wave were tried.

Consequently, it became clear that a certain amount of medical evidence exists in a pulse diagnosis. After observing this result, the animal experiment using the animal holding the same weight as Japanese and an Oriental people was conducted. And it was shown clearly medically that blood circulation dynamic state dynamics change influences change of a pulse diagnosis medically.

The clinical test was performed after that and medical data analysis of the pulse diagnosis in a human body was performed. Chaos analysis using nonlinear dynamics theory was performed to the time series wave obtained clinically.

The scientific method that not only depending on diagnosis of mere empiricism but high reproducibility is required.

We have to evolve a pulse diagnosis to scientific quantitative diagnosis.

For quantitative diagnosis, chaos theory analysis by mathematical dynamics theory was also performed, and clinical application was tried. It not only performs frequency analysis like FFT, but it added chaos analysis to the fluctuation component of a blood circulation dynamic state time series curve by the use of embedding technique.

By this method, the quantitative diagnosis based on nonlinear dynamics theory was tried. Consequently, the strange attractor reconstructed in the higher order phase space was observed.

It may be based on the influence of a reflected wave that the nonlinear dynamical system is complicated as going to a peripheral. Since participation of autonomic nerve information may be suggested to this result, it is interesting.

In an Oriental Medicine, various schools, such as Korea medicine, Chinese medicine, and Japanese tradition medicine,

exist. Since the pulse-diagnosis method which is different, respectively is in each school, medical approach has been barred. Since the diagnostic method changes with schools, scientific approach is barred.

For example, by the pulse diagnosis of a Chinese medicine, the pulse wave by the side of the heart shows the factor of the heart, and a peripheral side shows the factor about a intestine mediated by the central nervous system. The autonomic nervous system governs the dynamics of peripheral circulation. Therefore, it may be unable to be said that the participation of a central nervous system of a peripheral wave is large.

The result of this research cannot deny that it may also be in agreement with heart diagnosis of a Chinese medicine, and cranial nerve diagnosis.

Like this result, a scientific and quantitative diagnostic method which is represented with a pulse-diagnosis machine may be able to give a scientific basis to experience of the pulse diagnosis in a Chinese medicine.

Of course, it is predicted that the wrong diagnostic method and methodology exist in tradition medicine. If proof is studied by reproducible scientific diagnostic apparatus, a part of methodology of tradition medicine may remain as advanced modern medicine.

Now, the apparatus development which can spread through clinical is tried based on our knowledge in a developmental stage.

A scientific light can be put in performing quantitative analysis by scientific apparatus to the world of the Oriental Medicine for which it has so far depended only on experience.

Research continuance as a new direction, which evolves an Oriental Medicine to science, will be desired.

In the disaster area, all life line had been terminated. So, simple and easy diagnosis and treatment method had been useful. Electric doctor's bag was useful device in the Tsunami

area. Pulse diagnosis machine is simple and easy device. So, it may helpful for the people in the disaster medicine.

V. CONCLUSION

Non invasive portable device is useful when we consider the disaster shelter. Simple and easy method had been desirable, because the life line was limited at the time of disaster. So, oriental medicine may be useful. Scientific, quantitative and reproducible Pulse diagnosis Machine had been invented and evaluation with Moc circuit, animal test, and clinical application was performed in this study. Scientific evidence may be able to be given to a pulse diagnosis for the first time in the world using invention of this pulse diagnosis machine. Electric doctor's bag with pulse diagnosis machine may be useful device for the disaster in near future.

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(助成の明示)

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(感想)

おかげさまできれいにまとまりました