Abstract

According to the phenomenon-taking of classified analog, directional solidification can be an excellent approach for international communication of traditional Chinese medicine (TCM) in the context of COVID-19 pandemic. Attitudes toward TCM by Western Medicine (WM) can be represented by various morphologies of the solid/liquid interface. COVID-19 has created an urgent need for the worldwide spread of TCM. To counter any doubts and objections against TCM, COVID-19 pandemic provides a good opportunity, meanwhile a steady and firm pace forward should be kept. It is also necessary to resolve domestic controversies and to lower cultural shock. The philosophy of TCM can agree fairly well with dialectical materialism; the scientific connotation of pentacy in TCM can be explained through the symptoms of COVID-19-infected patients. A TCM understanding compatible with WM will accelerate its international acceptance, which could help to better elaborate the significance of humanity in TCM. Holistic medicine under the guidance of TCM principles is an important trend in medical development, whose framework is illustrated in a 4C+T diagram.

Keywords: COVID-19, directional solidification, international communication, traditional Chinese medicine

Introduction

It had been reported that up to 19,869,127 people had been infected by COVID-19, and among them, 731,453 had died throughout the world as of August 10, 2020. What is worse, everyday, there are still more than 100,000 new cases. On June 22, 2020, the World Health Organization’s director-general, Tedros Adhanom Ghebreyesus, told an online conference that the novel coronavirus pandemic was still accelerating and its effects would be felt for decades. It can even be regarded as the Third World War between human beings and COVID-19 pandemic.

Just as Sweden pathologist Folke Henschen wrote in The History and Geography of Disease, “Human history is also the history of diseases.” The Athens Plague outbroke in 430 BC resulted in the decline of Greece; the five plagues which had started in 165 AD led to the collapse of the Roman Empire, but then to the rise of Christianity; smallpox, communicated by African slaves in 1507, caused the deaths of large numbers of American Indians and the white settlers in America; the Black Death caused by pestilence originated in Central Asia but spread throughout Europe, and it lasted for nearly 300 years, resulting in almost 300 million deaths which was more than twice the number of deaths during the two world wars, till the termination of the 100-year war between Britain and France.

Five hundred and fifty seven plagues have been reported in the written history of China. In recent decades, severe plagues also occurred in China, such as Hepatitis A in Shanghai in 1988 and severe acute respiratory syndrome (SARS) in Guangzhou in 2003. Traditional Chinese medicine (TCM) has been used to fight effectively against these terrible outbreaks; outstanding...
TCM books, such as *Shang Han Za Bing Lun* (《伤寒杂病论》 Treatise on Cold Damage and Miscellaneous Diseases) by Zhang Zhongjing (张仲景) and *Wen Bing Tao Bian* (《温病条辨》 Systematized Identification of Warm Diseases) by Wu Tang (吴塘) recorded the successful experience and formulas for plagues.

In the fighting against COVID-19 pandemic, various western medicines have been tried but have not yet showed satisfactory curative effects; vaccines are being developed through arduous efforts, but still it takes a long time before they may be effective. However, clinical application of TCM medicines, especially the three medicines: Jin Hua Qing Gan Granule (金花清感颗粒), Lian Hua Qing Wen Capsule (连花清瘟胶囊), Xue Bi Jing Injection (血必净注射液) and three formulae: Qing Fei Pai Du Decoction (清肺排毒汤), Hua Shi Bai Du Formula (化湿败毒方), Xuan Fei Bai Du Formula (宣肺败毒方), have exhibited curative effects in more than 90% of treatments. Other TCM applications such as acupuncture and moxibustion, Tuina, and Tai Chi also contributed to early stage treatments and recovery. No mild symptoms have become severe after such TCM treatment.[8]

On the other hand, modern technology and Western Medicine (WM) play important roles in the early detection of fever and nucleic acid, as well as the utilization of life-support systems, such as extracorporeal membrane oxygenation in the intensive care unit (ICU). Other effective measures include wearing masks, social distancing, and washing hands.

Although TCM has achieved outstanding curative effects, it is not yet recognized worldwide because of the theoretical gap between TCM and WM and the complexity of TCM formulas. According to a recent survey sponsored by the China Foreign Languages Publishing Administration, TCM is the second most representative symbol of Chinese culture.[7] With TCM international communication and mutual understanding between TCM and WM, TCM will surely play a key role in the development of future medicine, and in the development of community of common health for mankind.

Therefore, it is necessary to have a “third eye” on the general framework for the international communication of TCM during COVID-19 pandemic, from which related factors can be analyzed and summarized logically. From the traditional thinking of phenomenon-taking of classified analog, directional solidification (DS) in science and technology can be an excellent approach to improve the international communication of TCM.

**A Brief Introduction to Directional Solidification**

In DS, a material is first melted by heating, then a cooling medium (such as a chill plate) is used at the bottom to release the heat; thus, a temperature gradient is built up and the material will solidify along with its movement from the bottom to another end [Figure 1].[9]

S/L interface plays a key role in DS, whose morphology determines the microstructure of the solidified material into its various properties. Figure 2 explains the reason for the morphological change of the S/L interface. The real temperature gradient and liquidus temperature depends on the solute composition being together in order to determine the supercooling in the liquid ahead of the S/L interface.

Planar solidification is most important in the growth of single crystals, including semiconductors for integrated circuit chips, oxides for laser systems, and also other optical applications, such as oxides for jewels and so on.

The condition necessary to maintain a planar S/L interface (no supercooling) is:

\[
\frac{G_L}{R} \geq \frac{m_l C_0 (1-k_o) z^2}{D_L k_0} \quad \text{Eq. (1)}
\]

where, \(G_L\) is the temperature gradient ahead of the interface, \(R\) the interface moving rate, \(m_l\) the liquidus slope, \(C_0\) the original composition or impurity content of the material, \(D_L\) the diffusion coefficient of solute in liquid, \(k_0\) the partition coefficient defined by \(C/C_L\).

Hence, if it is required to maintain a planar interface, \(G_L\) should be high, \(R\) slow, \(m_l\) not steep, \(C_0\) not high, solute diffusion in liquid \((D_L)\) rapid, and solute partition \(k_0\) approaches unity.

**Analog of International Communication of Traditional Chinese Medicine with Directional Solidification**

It is the traditional thinking in TCM to take phenomena by classified analog. After a careful analysis of TCM international communication, according to the attitude of WM, it can be determined that DS can be a good analog to explore various factors that affect TCM communication [Figure 3].

In DS, for different solute concentrations, with the change of \(G_L/R\), the morphology of the S/L interface undergoes a variation from planar to cellular, cellular dendrites, columnar...
dendrites, and equiaxed dendrites, which are illustrated in Figure 3. Equiaxed dendrites have a chaotic morphology, which can be likened to the ostracizing attitude of WM that sees TCM as a pseudoscience to be thoroughly abolished; columnar dendrites have a certain direction but there are a lot of sub branches, which is like the controversial attitude of WM in thinking of TCM as mysterious metaphysics and considering TCM to be irrational although it is proved to be effective in the treatment; cellular dendrites are a separated parallel array, which is similar to the complementary medicine of TCM, such as acupuncture and moxibustion, cellular morphology is a very shallow separation, which can be represented as alternative medicine in which not only medicine and techniques but also TCM theory can be an alternative choice of WM; finally, planar morphology to grow a single crystal is like holistic medicine in which TCM and WM are organically integrated into one totally new medicine.

Furthermore, factors which influence TCM international communication resemble the terms in Eq. (1) as follows:

- $G_L$, COVID-19 pandemic has brought about a chaotic world which has an urgent demand for TCM;
- $R$, the pace (methods and actions) for TCM international communication;
- $m_L$, culture shock incurred by TCM communication;
- $k_0$, controversies between China and the Western world;
- $D_L$, acceptance of TCM terms by the Western world;
- $C_0$, domestic disagreements about TCM.

COVID-19 pandemic has stimulated an urgent demand for TCM, which had been so effective before the successful development of western medicines and vaccines. A steady and gradual pace is necessary to help TCM communication, but those efforts to communicate TCM like flood irrigation are harmful. It is necessary to clear domestic disagreements concerning TCM’s various aspects. Because of the outstanding achievements of the Chinese government to put down COVID-19 by combining applications of TCM and WM, foreign countries will feel quite uneasy when facing their own serious situations. This represents a kind of cultural shock for those who feel they have civilization superiority. To dissolve the culture shock, identification of TCM by WM is of particular importance to develop community of common health for mankind. Thus, the understanding of TCM terms and theory in the Western world requires significant improvement.

**How to Accelerate Traditional Chinese Medicine International Communication**

By an analog of DS, various complicated factors which influence TCM communication can be taken into account.
by an equation, and the present attitude of WM toward TCM can be illustrated pictorially. Furthermore, it is necessary to identify specific solutions to accelerate TCM international communication. Why does TCM have such magical effects against COVID-19? The reasons may be listed as follows.

**Traditional Chinese medicine philosophy is in a naturale equivalency to dialectical materialism**

The most fundamental philosophy of TCM is “unity between man and nature balanced Yin and Yang,” which is perfectly depicted by the diagram of Tai Ji (DTJ), a wonderful visualization of dialectical materialism[9]. This can be understood as follows:

a. The world is connected universally: If we regard DTJ as the entire world, then any being is either Yin or Yang, and there must be another corresponding being to keep the balance of Yin-Yang

b. The world is in eternal moving and changing: DTJ circles around ad infinitum, moving and changing ceaselessly

c. Consciousness originates from matter, and reacts on matter: Consciousness is invisible which can be regarded as Yin; matter is visible which can be regarded as Yang. Since Yin and Yang are mutually rooted, so consciousness can change into matter, and matter into consciousness

d. Law of unity and conflict of opposites: Yin is both inside and opposite to Yang, always maintaining a balance which is unified by DTJ

e. Law of the passage of quantitative changes into qualitative changes: Extreme Yang leads to Yin, and extreme Yin leads to Yang

f. Law of the negation DTJ changes from Yin to Yang, and then Yin again.

This statement will help the Western world understand TCM more easily, so the cultural shock could be lessened.

**Scientific connotation of traditional Chinese medicine**

Clinically, in WM, drugs or vaccines are developed to attempt to kill the virus or infected tissue. This is identified as targeted therapy in precision medicine, similar to a laser guided missile used to bomb the enemy, which needs a very long period for research on the medicine or vaccine, but may become useless once the virus mutates.

However, the most fundamental principle of TCM treatment is to reinforce the healthy qi and eliminate the pathogenic factors, that is to say, TCM stimulates the patient’s own vitality and immune ability to fight against virus or diseases.

According to the theory of Wu Xin (五行 five elements or five phases), the underlying scientific logic of COVID-19 symptoms[10] can be explained in Figure 4.

When COVID-19 first invades the respiratory system, the human immune system will react with fever to kill the virus and with heat or cough to spit the virus out through phlegm. Because the respiratory function is damaged, not enough oxygen can be transported to human body to maintain normal metabolism, and the patient will often feel weak. The reproduction of COVID-19 is so rapid that their dead bodies may not be cleared away in time while massive immune antibodies are transported to the lungs, which will usually cause alveoli cysts (white lung) or immune hyperactivity. Since the lungs and large intestines are exterior-interior related, loose stool or constipation would happen. The activity of the kidney is directly connected by lung activities (kidney is very sensitive to oxygen), so the malfunction of the lung could lead to serious renal failure, and eventually into hepatomegaly. Renal failure will reduce the vitality of the heart, causing congestive cardiomyopathy. Hepatomegaly could result in atrophy of the spleen, and also cause exterior-interior related stomach issues, such as vomiting and diarrhea. The nerve system is closely related to meridians and channels which transport pneuma-hemo (Qi and blood) throughout the human body, so it can also be seriously infected by the virus.

During the treatment with TCM, the most important thing is to prevent the immediate malfunction of the lungs in case of the secondary harm to the other viscera organs. In Edition 7 of TCM therapies recommended by National Health Commission,[11] Ma Huang (麻黄  Herba Ephedrae) is commonly used, which has mild effect and tastes spicy and bitter. It is attributed to the lungs and urocyst channel in TCM, which has the functions of releasing muscles and skin to prompt sweating, dissolving phlegm and stopping coughs, nourishing Yin and astringing the lungs, transporting water and dispelling dampness. Sweating can excrete the metabolic waste and lessen the burden on the kidney, dissolving phlegm and stopping the cough will help to prevent over activity of the immune system.

TCM is different from WM in that it is a holistic treatment aimed at several human systems according to their correlations rather than a precise targeted therapy. This is often termed as multi-centered and multi-targeted treatment.
To clarify the scientific connotation of TCM is another way to reduce culture shock.

**Traditional Chinese medicine discourse compatible with Western medicine**

It is necessary to clarify the connotation of TCM for the foreigners. TCM terminology translation at present are not satisfying. Many TCM terms are not easily understood by Westerners, such as Yin-Yang, five elements, Zang-Fu, channel (meridian), even some simple words are different from Western terms, for example, xin (心) is different from heart.

This results in even greater cultural differences and controversies about TCM. As mentioned by Xuesen Qian, “The weakness of the TCM doctrine is that it cannot agree with modern science and technology, there are two sets of languages and concepts,”[12] so it is of great significance to develop a TCM dialogue compatible with WM. As illustrated in Figure 5, the present translation is to find Yang in Yin (to explain the scientific connotation in terms of TCM cultural circumstances), a better translation might be to find Yin in Yang (to explain the cultural meaning of TCM in terms of WM scientific circumstances).

Each term in TCM discourse is like a solute atom in the melt, its diffusivity reflects the acceptance by WM. Therefore, TCM terms that are compatible with WM can increase $D_L$ so as to maintain a positive communication of TCM.

**To construct holistic medicine under the guidance of traditional Chinese medicine theory**

The outstanding clinical effects against COVID-19 by the combined application of TCM and WM with the integrated traditional and Chinese medicine indicate the future of the modern medical system. Holistic medicine can be constructed following the framework illustrated in Figure 6.[13]

In Figure 6, holistic medicine can be constructed by a 4C+T framework (where 4C refers to the four circles, T is short for translational medicine) under the guidance of TCM principles, such as wholeness, balance of Yin-Yang, to treat ahead of disease, differentiation by three factors, health care, and so on.[14] In the center of the four circles is evidence-based medicine, which is crucial to verify these theories. The first circle is 5P medicine (predictive, participative, preventive, personalized, and precision) which coincidently agrees with pentacy. The overall goal of 5P medicine is a system medicine based upon cell biology and molecular biology. Then it is holistic integrated medicine that tries to bridge the gap between TCM and WM, for example, time medicine. According to the rule of differentiation by three factors, there is also a need for geography medicine, such as endemic disease. Outside the four circles is translational medicine which translates research results into clinical practice.

The construction of holistic medicine is like a single crystal growth during DS, as shown in DS by lowering $m_c$, increasing $G_L$ and $D_L$, and letting $k_0$ approach unity. Holistic medicine is of great significance to the mutual understanding between TCM and WM, which is crucial to develop community of common health for mankind and build a human community with a shared future.

**Conclusion**

In summary, DS can be a good analog for TCM international communication facing COVID-19 pandemic. Morphologies of S/L interface vary in terms of the ratio of $G_L/R$ which are planar, cellular, cellular dendrites, columnar dendrites, and equiaxed dendrites respectively. The phenomenon-taking of the classified analog of these morphologies, with a fair attitude toward TCM for WM, corresponds to holistic medicine, alternative medicine, complementary medicine, metaphysics, and pseudoscience.

COVID-19 can be thought of as heat input which pushes the present world to be chaotic and an urgent need ($G_L$) against the worldwide spread of TCM. To help remove the doubts and objections against TCM, a steady and firm pace $R$ should be kept. On the other hand, domestic controversies ($C_0$) should be
resolved. It is necessary to lower the culture shock ($m_i$), thus the philosophy of TCM can be addressed to agree perfectly with dialectical materialism; the scientific connotation of pentacy in TCM can be clearly understood based upon symptoms of COVID-19 infected patients. A TCM dialogue compatible with WM will accelerate its international communication ($D_i$), so it is necessary to determine the art and humanity implications of TCM terms in Western scientific circumstances. Holistic medicine ($k_o$) under the guidance of TCM principles is the greatest trend of medicine development as illustrated by a 4C+T diagram, which can significantly help TCM international communication.

To maintain a constant and positive international communication of TCM is crucial for the construction of community of common health for mankind and a human community with a shared future.

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Conflicts of interest
There are no conflicts of interest.

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