

Traditional Chinese medicine in the upcoming radiation era

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Since August 24, 2023, 1.3 million tons of contaminated water from the Fukushima Daiichi Nuclear Power Plant would be discharged into the Pacific in controlled batches^[1]. Furthermore, 5.5 tons of radioactive water containing cesium, strontium, and other radioactive materials spilled in early February 2024. This situation is emblematic of the higher doses of environmental radiation currently affecting the general public, who can be faced by the health risks associated with excess exposure to ionizing radiation.

Radiation injury is a complex condition involving multiple organs, tissues, and systems^[2]. In the recent fight against COVID-19, the capacity of traditional Chinese medicine (TCM) to treat complex diseases was widely recognized. Similarly, TCM can be applied unique therapeutic regimens to address radiation injuries, whether external, internal, acute, or chronic. Prior reports have indicated several recommendations for the application and research on TCM for radiological protection.

First, it is important to understand that the pathogenic factor underlying radiation injury is irradiation, which contains enormous energy and can disrupt the balance between *yin* and *yang in vivo*. The author's group investigated and analyzed the use of TCM syndromes based on the clinical manifestations of irradiated patients, and clarified the characteristics and evolution rules of irradiation injury. Subsequently, an anti-radiation plan of "clearing heat and detoxifying in the early stage, activating blood circulation to remove blood stasis in the middle stage, and nourishing blood and tonifying blood in the late stage" was raised. In cases of external exposure to radiation, TCM formulas can exert anti-radiation effects on the hematopoietic system, the immune system, the gastrointestinal tract, and the reproductive system. Huangqin tang, Baitouweng tang, Siwu tang, Sijunzi tang, and other decoctions are representative decoctions used under the guidance of the TCM anti-radiation plan. For internal exposure, blocked absorption of radionuclides and accelerated excretion

are required. Seaweeds, kelps, and diuretic herbs containing tongfu are representative TCM used in internal irradiation therapy.

Second, efforts to reduce the risk of radiation to health can benefit from the accelerated scientific research and development of TCM. Indeed, the efficacy evaluations of TCM cannot be limited to public praise and medical reports. Making full use of the various advantages of integrative medicine and new biotechnology may help to build new standards. In this context, Professor Yue Gao's research group has played an exemplary role in the evaluation of anti-radiation TCM^[3]. Siwu tang, which comprises *Rehmanniae Radix*, *Angelica Radix*, *Chuanxiong Rhizoma*, and *Paeoniae Radix*, was used as the model drug in their research. The anti-radiation activity of this concoction was evaluated at three chemical levels (whole prescription, effective parts, and effective ingredients) and four pharmacological levels (whole body, organs, cells, and molecules) using bioinformatic, proteomic, metabolomic, and single-cell spatiotemporal omic analyses, in addition to systems biology and other experimental pharmacological methods. The beneficial effects of Siwu tang on radiation injury to the hematopoietic, immunologic, gastrointestinal, and nervous systems were proposed through systematic research. The material basis and anti-radiation mechanism of Siwu tang were clearly demonstrated in this study. For patients and clinicians, these studies were conducted to understand the scientific basis of TCM, and to provide valuable data for the use of medicine in clinical practice. Similar studies on anti-radiation TCM are currently being conducted abroad. Therefore, international collaboration should be encouraged.

Finally, TCM involves the discovery of new drugs for the treatment of complex diseases, such as radiation injury. The natural products used in TCM have multitarget effects and complex structures that are difficult to achieve through artificial synthesis. According to the guidelines of the basic TCM theory

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system in the whole and dialectical thinking, new combination drug candidates against radiation injury may be found earlier and faster. This will help TCM to better satisfy the health needs of patients while providing doctors with more choices of available anti-radiation drugs.

Conflict of interest statement

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Ethical approval of studies and informed consent

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Data availability

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