

# Current status of radiology in China

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## INTRODUCTION

Radiology has been greatly advanced in China since its founding in 1949 and has been developed faster and further more since China adopted the policy of socioeconomic reform in 1978. It plays an increasingly important role in the medical health care and treatment in the country and has reached the world's advanced level in certain fields. We now briefly review the history of China's radiology so as to give a clear picture of its development.

## BRIEF REVIEW OF THE HISTORY OF CHINA'S RADIOLOGY

The first X-ray machine was imported and used in clinic by Kailuan Hospital of Hebei Province in 1911<sup>[1]</sup>, followed by a few missionary hospitals in Beijing and Shanghai. The first X-ray machine designed and produced by China was born in Shanghai in 1952<sup>[2]</sup>. The early head and body CT sets were imported to Beijing, Shanghai and Tianjin, respectively from the beginning of the 1980's. It was a great event representing the commencement of CT imaging epoch in China. From then on, more and more scanners were imported and till now distributed in majorities of large and medium-sized hospitals. In the Chinese radiologic history, several eminent radiologists who made great contributions to the development of Chinese radiology in different generations are worthy to be mentioned and commemorated.

The pioneer of Chinese radiologists was Professor Zhi-Guang Xie (C.K. Hsieh) of Peking Union Medical College (PUMC). After graduation he worked in the Department of Radiology in PUMC Hospital in 1923, and studied under the instruction of a famous American radiologist, Paul. C. Hodges, and became the chairman of that

department in 1928 after completing his radiologic research career in Michigan University of America. He also was the first Chinese doctor who held the membership of American College of Radiology. In 1948, he returned back to his hometown Guangdong Province and continued his practice and research in some affiliated hospitals of Sun Yat-Sen University of Medical Sciences until he died in 1966.

Among many radiologists trained by Professor Xie, and Drs. Du-Shan Rong and Zhao-Xuan Wang who are the most famous and regarded as the pioneers of China's radiology just as Professor Xie. Both of them graduated from PUMC in 1929 and 1933, respectively and worked as research fellows in radiology in America in the 1930s. After the year of 1949, Professor Rong became the Director of the Department of Radiology, Zhongshan Hospital, Shanghai Medical University and Professor Wang was the Director of Radiological Department, the First Affiliated Hospital, Beijing Medical University. Both of them owned the honorable membership of American College of Radiology. The three professors were considered as the founders of China's radiology. In 1952, they established the National Committee of the Chinese Society of Radiology and Chinese Journal of Radiology in Beijing. They contributed to the progress of China's radiology in training radiologists and initiating the clinical and research work, e.g., studies on the relationship between early lung cancer discovered by conventional X-ray examination and pathology, and establishing the criteria for the X-ray diagnosis and staging of silicosis. In 1956, Professors Xie and Wang collaborated in creating the formulae (called Wang-Xie Formulae) to calculate the surface area of the heart of the Chinese people. Professor Wang passed away in 1986. Professor Rong had a very important book entitled "X-ray diagnosis" published with three volumes in 1978 as the chief editor. By now, the second and third edition of the book have been published and still considered as the classical and necessary reference for Chinese radiologists. Professor Rong died of renal cancer in 1988.

Among the 2nd or the 3rd generations of Chinese radiologists, there are also many distinguished radiologists who have made great contributions to the Chinese radiology, especially in the advanced modern radiologic techniques and researches. Among them, Professor Guo-Zhen Li, Yu-Qing Liu and En-Hui Wu are admitted as the most distinguished ones. Professor Li is now working at Beijing Hospital. She also graduated from PUMC in 1943 and spent three years in Billing's Hospital, Chicago University during 1948-1950. Recently she was awarded as the honorary

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Dr. Meng Su Zeng, graduated from Nanjing Medical University in 1986, and earned M.D. from Shanghai Medical University in 1995, now associated professor of radiology, and specialized in radiologic diagnosis and studies of abdominal diseases, having over 30 papers and two books published.

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membership in the committee of RSNA. Her book entitled "Clinical Body CT Diagnosis" published in 1986 and 1994, which helps a great deal in popularizing and enhancing CT knowledge throughout the country. Professor Liu is the major founder of cardiovascular radiology in China, now working in Fuwai Hospital of PUMC and has been appointed as the Honorary President of Chinese Society of Radiology since 1993. He is the academician of Chinese Academy of Engineering (Division of Medicine and Health), the only one working in the field of radiology. Professor Wu, presently working in the General Hospital of Tianjin Medical University is one of the founders of neuroradiology in China. He is the first Chinese radiologist ever elected to the honorary membership by the Committee of RNSA in 1988. These three radiologists have made great contributions to the development of Chinese radiology. Now many eminent radiologists of new generation have emerged in different fields of radiology.

#### RADIOLOGICAL EQUIPMENT AND DISTRIBUTION IN CHINA

There is great difference in the radiological equipment distribution between urban and rural areas in China because of the obvious difference in the medical care system and economic conditions. In general, the amount of radiological equipment in cities and rich areas (e.g. eastern coastal area) is larger than that in rural and poor areas. In general, large hospitals such as university hospitals, teaching hospitals and provincial hospitals have all been equipped with DSA, CT, MRI, ECT, color Doppler US, etc., some of them are in the state-of-the-art (e.g., spiral/helical CT, ultra-fast CT, PET and super magnetic strength MRI). Those hospitals represent the whole medical care level of our country. Medium-sized hospitals such as city central hospitals and county hospitals have also been supplied with conventional CT and Doppler US in the developed economic areas, and some of them even with the spiral CT, MRI, ECT and DSA. A few of district hospitals and community health centers have also purchased the conventional CT and Doppler US, but majority of city central hospitals and county hospitals still have not been installed with CT and Doppler US in the undeveloped economic areas, especially those hospitals of the impoverished rural areas possess only the conventional X-ray machines and ultrasounds (including GI X-ray machine and fluoroscopic X-ray machine). Basically all of hospitals (including urban community health station and rural community health central) have been equipped with conventional X-ray machines and ultrasounds around the whole nation. According to the statistics, there are approximately 100 thousand X-ray machines of all kinds, 3 thousand CT, 3 hundred MRI and 2 thousand Doppler US by the end of 1997 in China<sup>[3]</sup>. Simultaneously great step

progress has been made in the design and home-made radiological equipment since China adopted the reform and open-up policy in 1978. So far, China can make a variety of conventional X-ray machines with the capacity below 800mA, and some of them have been exported to African and Asian countries. Through setting up the joint enterprises with GE and Siemens companies, the whole body CT scanners were produced in China beginning from 1987. The Chinese Academy of Sciences has produced the real time ultrasound of high quality in cooperation with some developed countries in 1988. Meanwhile the 0.15T MRI of permanent magnet model, was developed and produced successfully, with some imported electronic elements. The imaging quality of this MRI machine is high enough to display the neuro-system with recent improvement of both software and hardware. Now China has began to study and develop the 0.2T MRI of new type which already has been installed and put into use in some hospitals. All these indicated that China has the capability of producing some imaging equipment<sup>[4-13]</sup> in some aspects.

#### MODES OF RADIOLOGICAL DEPARTMENT AND EDUCATION IN CHINA

In general, the mode of the department of radiology in Chinese hospital is quite different from that of western countries. The divisions of ultrasound and nuclear medicine are independent disciplines and separated from the department of radiology in most of the hospitals, with little involvement in the academic activities. Ultrasonographers are trained differently from radiologists. Only a few hospitals, have merged the US, nuclear medicine and radiology into a unified department in both organization and specialty. The Ministry of Public Health has pronounced in 1990 that the department of radiology should become a clinical department if it is able to carry out interventional therapy independently. This means that the staff of radiological department shared the same responsibility and right as those of clinical department. Since then, the interventional therapy in China has made a great progress, and many hospitals have established the division of interventional therapy within the department of radiology and trained a lot of doctors under this discipline.

Great importance has been attached to the medical education and the training of radiologists as well. Among the 126 medical universities (schools) or colleges with clinical medical discipline, 7 medical colleges had medical imaging discipline<sup>[14]</sup>. A part of students enter the department of radiology as residents after 5-7 years of study at college. A proportion of young radiologists pursued graduate studies for 3-6 years if they passed the required examinations. They are promoted through several years of practice to a higher position according to their experiences, achievements of clinical work and

number of published papers (generally, become an associated professor after 2-5 years, and a professor after 5-7 years). The title and length of education for fellows are different from that of America. Ph.D. (namely medical fellowship in America) can be trained and obtained in only 8 authorized medical schools, including Beijing Medical University, Shanghai Medical University, Tianjin Medical University, Peking Union Medical College, West China Medical University, Sun Yat-Sen University of Medical Sciences, The Second Military Medical University and the Fourth Military Medical University<sup>[15,16]</sup>.

### CURRENT RADIOLOGIC CLINICAL PRACTICE AND RESEARCH IN CHINA

During the past 15 years, Chinese radiologists have accumulated a lot of clinical experience and made some valuable researches in CT, MRI, interventional radiology, angiography, ultrasound, nuclear medicine, etc., Approximately 10 thousand papers have been published in all kinds of Chinese radiological journals and periodicals (Table 1), but relatively a small number of research articles are submitted to western journals, because of the English language barrier.

**Table 1 Main Chinese journals of radiology**

1. Chinese Journal of Radiology (Beijing), established 40 years ago
2. Journal of Clinical Radiology (Huangshi)
3. Journal of Practical Radiology (Xi'an)
4. Journal of Clinical Medical Imaging (Shenyang)
5. Chinese Journal of Medical Imaging Technology (Beijing)
6. Roentgenpraxis (Wuhan)
7. Journal of Foreign Medicine: Clinical Radiology (Tianjin)
8. Chinese Medical Abstract: Radiological Diagnosis (Wuhan)
9. Chinese Journal of Medical Imaging (Beijing)
10. Journal of Interventional Medicine (Shanghai)
11. Chinese Journal of Medical Computed Imaging (Shanghai)
12. Modern Medical Imaging (Xi'an)
13. Medical Imaging (Tianjin)
14. Journal of Diagnostic Imaging & Interventional Radiology (Guangzhou)

### CT

Clinical applications of CT technique have gradually been popularized throughout the country. Before the invention of spiral CT, dynamic incremental CT enhancement scanning was performed and adopted in most of the hospitals, mainly for detection of focal hepatic lesions. In addition, CTA and CTAP were also used for discovering the small primary and secondary hepatic lesions in the selected cases. In recent years, imported spiral CT scanners were installed in most of the large hospitals, some new techniques and researches regarding spiral CT (such as CT angiography, multi-planner or 3D imaging of bronchus, bone, etc.) were developed, particularly in university hospitals. Dual phase or multiphase spiral CT enhancement procedures were studied primarily in small hepatocellular carcinoma as well as in pancreatic and renal cancers. It was proved to be very sensitive in detecting the small neoplastic

lesions, in particular the hypervascular masses in liver during the arterial phase or combined phases. HRCT technique was used routinely in pulmonary cancer, single pulmonary nodule and diffuse pulmonary diseases. Special CT procedures for digestive tract, including mainly recto-colonic cancer and gastric cancer by filling those organs with ordinary water were successfully investigated, and the protocol accompanied by pronounced enhancement improved greatly the accuracy of the tumor staging. All kinds of CT training programs for radiologists were offered annually by the senior radiologists in order to improve their clinical experiences, master the new techniques and overcome some pitfalls. In a couple of hospitals in Beijing and Shanghai, electronic beam CT (UFCT) was available and the comparative studies of the detection and quantitative measurement of the calcification on the coronary arterial wall with angiography were performed to estimate the risk of the coronary heart attack<sup>[17-22]</sup>.

### MRI

Since 1990, more MRI equipment have been imported to our country, different magnetic strengths of MRI machines have been installed in lots of large hospitals as well as in a few of medium-sized hospitals. In many hospitals, most cases of MRI inspection are still devoted to neurological system and skeletal system. MRI examination is mainly carried out to find the early cerebral ischemia and neurological tumors in many hospitals. Some university hospitals have used MRI to investigate a series of changes about cerebral ischemia and hemorrhage and compare with pathology in order to guide the clinical treatment. Investigation of MRI in skeletal system includes mainly the tumor of bone and soft tissue, trauma and other diseases of the joints. Significant achievements and good experiences have been obtained in studies on cardiac ischemia, cardiac infarction and reperfusion after infarction with dynamic enhanced MRI scans in comparison with isotope examination and coronary angiography in some hospitals (main university hospitals). MR angiography (MRA) was done successfully in cerebral, carotid and limb arteries, but with unsatisfactory results in thoracic and abdominal aorta and their branches. Over the past two years, 3D dynamic contrast enhanced MRA has been developed with improvement of imaging quality, such enhanced MRA technique was also applied to venous system, particularly to the portal venous system which can be shown simultaneously with hepatic veins and inferior vena cava as well as their collateral in cirrhotic cases. The good results have been yielded in more than 100 cases by this exams from Zhongshan Hospital, Shanghai Medical University. Other new MRI techniques such as MR cholangiography (MRC), MR cholangiopancreatography (MRCP), MR urography (MRU) and

MR myelography (MRM) aroused great interest and were improved with introduction of single shot SE sequence. According to the report of Zhongshan Hospital of Shanghai Medical University, fast dynamic enhanced MRI was superior to SE sequence in identifying the early lesions and making differential diagnosis for abdominal organ diseases. For small hepatocellular carcinoma, it might be better than dual phase contrast spiral CT and should be considered as a supplementary method. Currently, some new techniques like MR spectroscopy, MR with specific liver contrast media, rectal endocoil for pelvic organs, diffusion and perfusion for early cerebral ischemia, functional MRI, etc. are being developed and will be applied in the near future<sup>[23-30]</sup>.

#### ***Interventional radiology and angiography***

Interventional radiology as a new branch of radiology was introduced into China in the mid 80's, and since then it has made spectacular progress. Transcatheter management of neoplasm is a very active field in interventional radiology and has been applied to the treatment of tumors at various sites of the body, especially for tumors of lung and liver. According to the statistics of Zhongshan Hospital of Shanghai Medical University, interventional treatments for liver cancer have been given to approximately 8000 advanced cases. The 1-, 2-, 3- and 5-year survival reached 65.2%, 35.3%, 24.6% and 9.8% respectively. In Changhai Hospital of the Second Military Medical University, the same work was carried out with similar result. The Chinese People's Liberation Army General Hospital and China Medical University Hospital have reported that they used TIPS technique for the treatment of portal hypertension and massive bleeding in about 500 cases with fruitful result. Several hundred cases with mitral stenosis have been treated by non-operative methods with excellent results in Fuwai Hospital of Peking Union Medical College, Guangdong Provincial Hospital and Jiangxi Medical University Hospital. In addition, percutaneous transluminal angioplasty was also widely used to dilate pulmonary valve, coronary and renal arterial stenosis and Budd-Chiari syndrome. Vascular and nonvascular stent placement for vessels, bronchus, esophagus, bile duct, etc. have also been performed, and preliminary clinical experience has been achieved. Percutaneous aspiration biopsy guided by X-ray, CT and ultrasound is widely performed in diagnosis and treatment for the lesions of liver, lung, kidney, pancreas and bone. The interventional diagnosis and treatment, (e.g. thrombolytic therapy for cerebral ischemia) are not very common in China and MRI interventional therapy is still unavailable. Many large and medium-sized hospitals have the advanced DSA X-ray machines used for all kinds of angiography such as coronary angiography and cardioangiography, but

the application is gradually decreasing as noninvasive procedures (i.e., MRA, CTA and color Doppler US), have come into being<sup>[31-35]</sup>.

#### ***Ultrasound and nuclear medicine***

Sonography is very popular in China, even being used for physical checkups because it is cheaper and safer and needs less time than other imaging modalities and easy to operate. The hospitalized patients basically received ultrasound examination on admission. Ultrasound (including color Doppler US and 3D US) is widely used for abdominal disease and heart disease and gynecologic and obstetrical diseases (including congenital and acquired heart diseases). The pregnant women undergo US examinations every 3 to 4 months in order to monitor the growth of the baby according to the physician's suggestion. In recent years, some new ultrasonic techniques have been put into clinical practice in a few hospitals such as contrast-enhanced US and endosonography.

Nuclear medicine departments and labs have been set up since the 1950s in many large hospitals and a few medium sized hospitals. Single photon emission computed tomography (SPECT) is mainly used for radiopharmaceutical studies and as a routine examination, it can provide diagnostic information in the setting of a nuclear medicine clinical services. Most of university hospitals have equipped this facility in China and has used it routinely and frequently in the investigation of the brain, the heart and the skeleton, especially in detecting the metastasis of bone. On the other hand, radioimmunological assay and analysis are also important parts of nuclear medicine. Positron emission tomography (PET) has been put into clinical practice in Shandong Province, Shanghai and Beijing, respectively. The Ministry of Public Health has approved Beijing and Shanghai to set up respectively clinical center of PET.

#### **RADIOLOGICAL TRENDS OF CHINA IN FUTURE**

In short, radiology of China has been greatly advanced over the past two decades and has played very important roles in the prevention and treatment of diseases, however, it is still in its developing stage. Some renowned radiologists in China have predicted that lots of hospitals will be supplied with spiral CT to replace conventional CT being used widely in clinical practice in 2-3 years. Some university hospitals will purchase the most advanced multislices spiral CT and multiple-functional MRI machine (e.g., possessing of EPI) in order to catch up the latest step of the world. Due to the need of clinical practice, development of PACS (picture archiving and communications system) continues to be a subject of intense interest and some university hospitals will be equipped with PACS, making the imaging transfer easier and quicker between radiological departments and clinical departments or among the divisions within the departments of radiology (including CT, MRI,

SPECT and US).

In regard to radiological research, the Chinese Society of Radiology recommended the improvement of early detection for small cancer such as small liver carcinoma, lung cancer and pancreatic cancer as the research objectives. In many hospitals, noninvasive procedures (i.e., MRA, CTA, MRCP and Dopple US) are being gradually substituted by the invasive procedures in radiological examination. Further studies are needed to get the optimal protocol of imaging modalities. Experimental researches in the field of radiology ought to be strengthened.

Lastly, radiology ultrasonography and nuclear medicine should be incorporated as a unified subject in term of administration and academic exchange in order to increase the accuracy of diagnosis and decrease unnecessary imaging examination. We are convinced that radiology of China will have a vigorous prospect and play more and more important roles in the care of people's health.

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