

Charles C. Reed Memorial Lecture

Footprint of History

The Development of Extracorporeal Circulation in China

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PRESIDENT JOSEPH SISTINO: We are very fortunate this year to have Dr. Fan, who is here from China. He is employed at the Shandong Provincial Hospital of the Medical School of Shandong University. He has a title of Professor of Surgery and he is also a trained perfusionist. As you know, about half of the perfusionists in China are physicians.

He is a member of AmSECT and is the chairman of Shandong Perfusion Society. He graduated from medical college in 1976 and began postgraduate training at that time. He has been at Shandong University from 1982 and was a surgical resident at both Great Ormond Street and at Guy's Hospital in London.

Please welcome Dr. Fan.

[Applause]

DR. FAN QUANXIN: Dear Mr. Chairman, dear friend and colleagues, ladies and gentlemen, good morning.

It is a great honor for me to be invited as the Charles C. Reed memorial lecturer to join the AACCP annual conference. First, I would like to show you a picture. This is the masterpiece in the extracorporeal technology, Cardiopulmonary Bypass, written by Charles Reed and Trudi Stafford, which was first translated into Chinese in early 1980s when I was a young cardiac surgeon as well as a perfusionist. This book is full of wisdom and deep insight in extracorporeal science, and has been my good friend and teacher ever since. Also it nurtured a whole generation of cardiac surgeon and perfusionists of my age. So we can say, Charles Reed had had great contribution and influence to the development of extracorporeal science in China. One of my purposes to be here today is on behalf of my Chinese colleagues to show our heartfelt respect to our great pioneer.

History of Development of Extracorporeal Circulation Science in China

Over half a century ago, when the modern cardiovascular surgery and extracorporeal circulation emerged in the West, our country just got rid of the

civil war which gave the country tremendous destruction and brought China to economic collapse. These pictures show the miserable life of ordinary Chinese people at that time.

The foundation of the new republic brought a new hope of national rejuvenation and the people cheerfully threw themselves into the construction of new China. Mao Zedong was looked upon as a national savior and was ambitious to make China a modern and strong country. Although Mao was a skillful and resourceful politician, unfortunately he had no knowledge of modern science and had no idea of democracy. He did not trust the intellectuals who had the western education background, and even thought they were a potential threat to the New Republic. At that time, most famous doctors and medical specialists had western education and work background and they were thought unreliable. Most of them were put out of important positions. So at the beginning, the tragic fate for the medical elite was doomed and the road for cardiovascular surgery would be tortuous and eventful.

In 1950s a serial exciting breakthrough took place in America and Europe, but China was separated from the outside world, the normal academic exchange was almost stopped. It was very difficult for the Chinese doctors and specialists to get information and data from the West. In such a situation, cardiovascular surgery in China broke the ice with tremendous difficulty.

On May 2, 1953, Dr Shi Meixin in Shanghai performed Blalock-Taussig shunt for a boy with Tetralogy of Fallot.

In February 1954, Dr Lan Xichun in Shanghai performed closed mitral commissurotomy for a patient with rheumatic mitral stenosis.

In 1957, in Shanghai Renji Hospital, Dr. Wang Yishan performed a pulmonary valvotomy without cardiopulmonary bypass (CPB).

On April 10, 1958, Dr. Shi Meixin performed ASD repair with moderate hypothermia.

By the end of 1959, open heart operations were carried out under hypothermia without CPB in 30 hospital in 13 provinces.

One of the brilliant figures in development of cardiovascular surgery and extracorporeal circulation in China is Dr. Su Hongxin who was born in Jiangsu province in 1915. In 1943, he graduated from the Medical School of Central University. In 1949, he went to Chicago, where he worked as a surgical resident in Northwest University Whisler Memorial Hospital and in Metropolitan Tuberculosis Hospital. In 1955, he worked as a postgraduate in Affiliated Hospital of Illinois State University. During 1954-1956, he visited the Mayo Clinic in Minnesota, where he met Dr. Kirklin and Dr. Lillehei, and was deeply impressed by the achievements of extracorporeal circulation technology and open heart surgery. At that time Dr. Su's talent and surgical skill were highly appreciated by his American colleagues. He received a Green Card, had a job for which he was well-paid and married a beautiful American girl. If he continued working in the United States, the future for him would be bright and promising.

He was determined, though, to devote himself to the newly emerged cardiovascular surgery in his motherland. He spent all his savings and bought two sets of Sigma Motor (finger pump) heart-lung machines.

His intention was discovered by the FBI, and at that time such machines were not allowed to be exported to Red China. Dr. Su had to change his course by way of London and Paris. He brought with him the precious machines, an entire set of surgical instruments and his beautiful wife. Dr. Su was back in China in February 1957.

He wasted no time, and started extracorporeal circulation experiments in animal models in Xi'an. He worked in the ECC laboratory day and night. After over one hundred experiments, the animal survival rate reached 78%. On June 6, 1958, Dr. Su successfully repaired a VSD for a 6 year-old boy. This is an epoch-making event in the history of cardiovascular surgery and extracorporeal circulation in China.

Before Dr. Su returned to China, in the summer of 1956, Chinese doctors and engineers began to make a home-made heart-lung machine. Dr. Ye Chunxiu successfully made a finger pump in 1957 in Shanghai.

From March 1957, Dr Gu Kaishi co-operated with Shanghai Medical Instruments Factory, to make a roller pump and a modified De Wall-Lillehei bubble oxygenator which was successfully used in patients in July 1958.

Dr. Shi Meixin co-operated with the coppersmith and built a screen oxygenator in 1958 in Shanghai Zhongshan Hospital. After nearly 200 animal experiments, the oxygenator was successfully used in clinical practice in 1961.

In 1957, Dr Wu Yingkai organized and built Fuwai Hospital (one of the biggest chest hospitals in the world) in Beijing, and independently started study of extracorporeal circulation and open heart surgery. They built a pump after Sigma Motor, and modified

DeWall oxygenator. In 1959 they performed a repair of Tetralogy of Fallot with deep hypothermia (22°C-26°C) and cardiopulmonary bypass.

Because the poor performance of home-made heart-lung machine and oxygenator, inspired by the "azygos vein principle", Dr. Zhang Tianhui and Dr. Wang Yuanchang created semi-body extracorporeal circulation technique.

The patient's body temperature was lowered to 30°C with surface cooling, further cooling to 25°C was achieved by perfusion, then the descending aorta was clamped and the ascending aorta was perfused at flow rate of 15-20 ml/(kg·min) to protect the brain. The heart was cooled by ice slush when the intracardiac repair was finished, the whole baby was perfused and rewarmed.

In our hospital the semi-baby extracorporeal circulation technique was incorporated with autologous lung oxygenation so that complicated cardiac procedures such as Tetralogy of Fallot repair could be accomplished.

In middle 1960s China-made heart-lung machine (Shanghai-II roller pump can be batch manufactured, disc oxygenator and bubble oxygenator were popularized, open heart operations could be performed in about 20 hospitals nationwide. The amount of cardiac procedure reached to about 600 in 1965.

From 1966-1976 the so-called "Cultural Revolution" took place in China. The whole nation fell insane, political persecution overwhelmed the country. The famous doctors and medical specialists were criticized as "reactionary academic authorities". They were deprived of rights to perform operations, driven out of universities and hospitals, forced to do labor works or exiled to remote, poor and backward areas. In 1966~1972 there were only two hospitals doing very few CPB operations (the amount nearly reached to zero). It was a time of nightmare for the medical science and cardiac surgery. Ten-years efforts made by the pioneers was nearly completely destroyed.

Open Heart Operations Performed In China

Year	1960	1965	1967	1972	1976
No.	12	300	<10	80	200

In the post-Mao era the government authorities took a realistic policies which was called “Reformation and Open to the Outside World”. The economy recovered rapidly the living condition and conditions of medical care resources improved dramatically. In the last 30 years the cardiovascular surgery made great strides forward. Foreign patents, techniques, and capitals were introduced to China. Many Chinese doctors and engineers were sent abroad to learn the newest knowledge. Economic and technique interchange stimulated rapid development of medical industry medical science.

Development of Domestic Instruments for ECC includes:

- 1978 Shanghai II roller pump
- 1980 Tianjin soft bag bubble oxygenator (after Polystan)
- 1982 Guangdong II hard-shell bubble oxygenator(multiuse)
- 1987 Xijing 87 hard-shell bubble oxygenator(disposable)
- 1992 Fudan membrane oxygenator (blood flows inside fiber)
- 1995 Xijian membrane oxygenator (blood flows outside fiber)
- 1998 Tianjin new roller pump (joint venture with Jostra)

Popularization of the following major techniques in ECC and myocardial protection greatly improved operation results and patients’ outcome.

- Late 1970s crystalloid cardioplegia
- 1980s additional protective agents added to cardioplegia (verapamil inderal etc.)
- 1994 blood protection (trasylol, aminocaproic acid, etc.)
- 1996 modified ultrafiltration
- 1990s blood cardioplegia and warm blood cardioplegia
- 2000 blood conservation
- 2004 ECMO

Open Heart Operations Performed In China

Year	1980	1990	2000	2005
No.	1,200	15,000	50,000	100,000

In Asia, China now does the most open heart operations (about half of total cases). As for the composition of cardiac operations, congenital heart defects made up 60%-65% of total cases, rheumatic heart disease about 20%-25%, and coronary artery disease 10%-20%.

In China, total amount 484 hospital are doing ECC operations and the number of perfusionists is about 1142. The National Society of Extracorporeal Circulation was established in 2004. We publish a journal of our own and the members of the society in 2004 numbered 606. 101,448 cardiac operations were

done in 2005 and the ratio of cardiac surgeon to perfusionist is about 3 to 1.

Among the Chinese perfusionists, 56% are doctors, 44% are technicians, 41% are full-time perfusionists and 59% part-time (they also do surgery, anesthesia, nursing, etc.). Although the perfusionists’ job is challenged by off-pump operations, the number of ECC cases is steadily increasing.

For the ECC equipment, 30% of the heart lung machines are domestic, 100% centrifugal pump are foreign, 10% membrane oxygenator are domestic, 100% bubble oxygenator are domestic. In recent years, more membrane oxygenators were used. In 1990, membrane oxygenators were employed in less than 10% of cases, it reached to about 30% in 2000, and now is over 50% of all cases. China-made membrane oxygenators occupied less than 2% in 1994, and now are up to 19%.

Among the 484 hospitals that can carry out open heart operations, only one quarter (24%) can do more than 200 cases per year, only 15 hospitals (3%) are performing ECC exceeding 1000 cases per year. In one third of hospitals, the operating amounts were less than 50 per year. It is noteworthy that one quarter bigger hospitals are doing two thirds of all cases. It means differences between hospitals are significant.

It is also interesting to compare cardiac surgeons in China and US. In US, there are about 4,100 cardiac surgeon and 3300 perfusionists, and the work load is 380,000 operations, averaging 93 cases for each surgeon and 115 cases for each perfusionist. Whereas in China, the averaging work load for each surgeon is only 30 cases per year, and 89 cases for each perfusionist. It looks like that the Chinese perfusionists are as efficient as their American colleagues, but the Chinese surgeons are not (we should remember in most Chinese hospitals cardiac surgeons do general thoracic cases as well).

In the United States, there are 0.3 billion people, the cardiac operation amount is 380,000; in Japan, the population is 0.12 billion and the cardiac operation amount is 35,000. In China the cardiac operation amount reached to 1,000,000. It is estimated by specialists that in China only 10%-20% of patients get necessary medical care, so the potential cardiac patient population should be as big as eight million. China is the largest potential medical market in the world. I am sure with further economic development that cardiac surgery and ECC in China will have a bright and prosperous future.

China is a beautiful country with friendly and hospitable people. In 2008 Olympic Games will be hold in Beijing. We welcome you to visit China and join us in Olympic Game in Beijing in 2008.

That is my presentation.
Thank you.