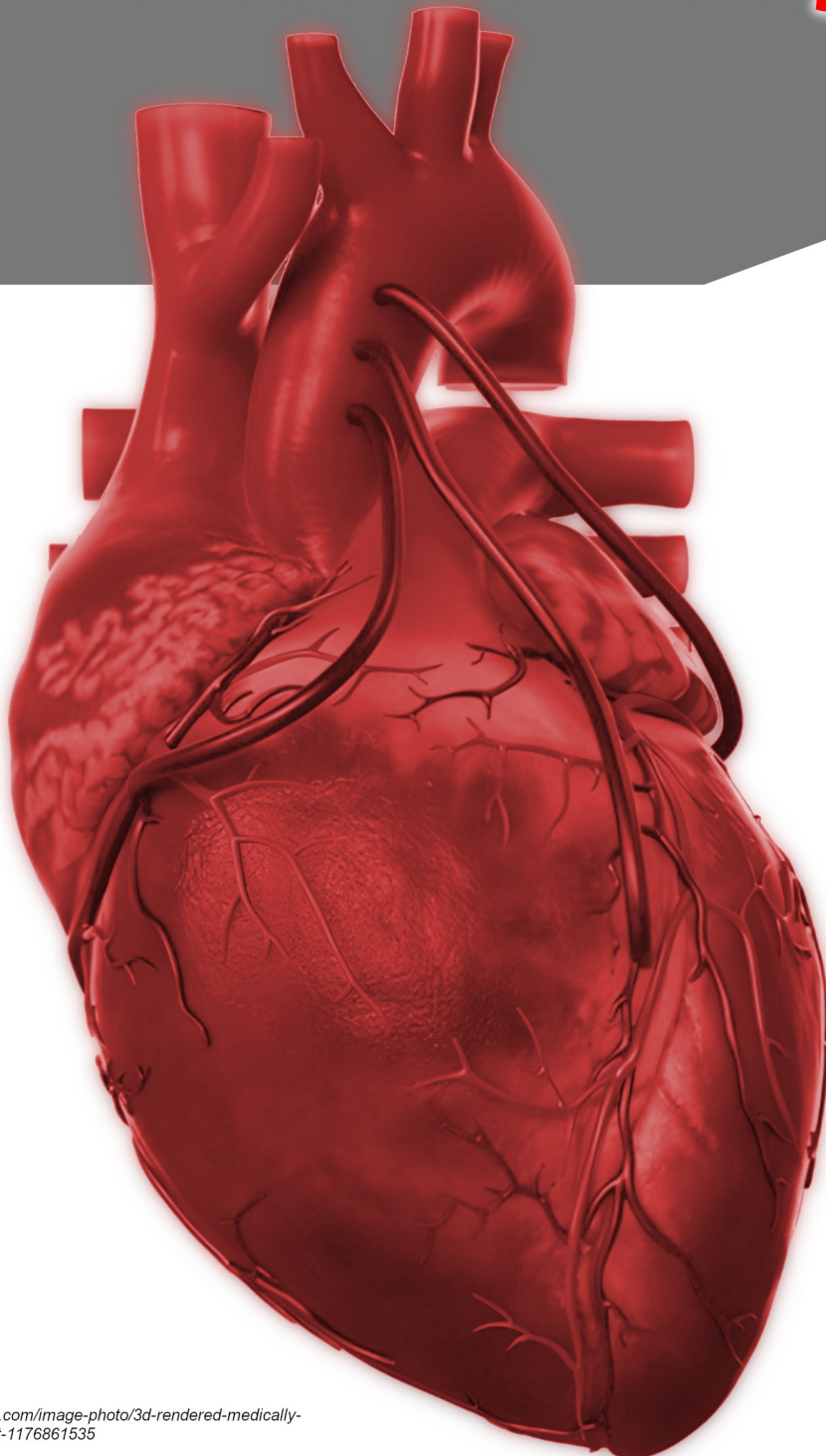


Enhanced External CounterPulsation (EECP)

The Untold Story



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Reviewed by:
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(Jan 2026)

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Prologue

The most profound journeys often begin with heartbreak. Mine started in 1997, sitting in a sterile hospital room with my wife, processing the news that we had lost our third baby in a row.

I'm a chartered accountant by trade—someone who deals in black and white, numbers that add up, problems that have solutions. Medicine, I was about to learn, doesn't work that way. Each time we lost a pregnancy around sixteen weeks, the doctors were kind but maddeningly vague. "These things happen," they would say. "Miscarriages before twenty weeks are common. Sometimes there's just no explanation."

But I couldn't accept that. In my world, when the books don't balance, you dig until you find where the error is. There had to be an answer.

That stubbornness sent me down a rabbit hole that consumed seven years of my life. I started showing up at medical conferences where I clearly didn't belong—a guy in a business suit surrounded by doctors and researchers. I traveled to American Academy of Anti-Aging Medicine conferences in the States, absorbing everything I could about alternative medicine approaches that conventional doctors rarely mentioned.

What began as a desperate hunt for answers slowly became an obsession. I enrolled in a two-year Diploma in Integrative Medicine at Swinburne University, swapping spreadsheets for hormone charts and biochemistry textbooks that made my head spin.

After seven years of this deep dive, I finally had my answer. It wasn't revolutionary—any doctor could have told me this—but for an accountant, it was a lightbulb moment: many health problems, including our pregnancy losses, stem from hormone deficiencies. My wife's miscarriages were likely caused by an incompetent cervix due to low progesterone.

Once we knew what we were dealing with and caught it early, we could address it. Today, our three sons are all thriving young adults—living proof that sometimes you have to dig deeper than the standard explanations.

That success got me thinking: if my accounting background helped me crack a medical puzzle that changed our lives, maybe I could help other people hitting the same walls with their health. I'm not a doctor, but those years of research gave me knowledge I could translate for regular people who didn't know where else to look for answers.

This led me to found Aalsum Pharmas Sdn Bhd, where we focus on compounding healthcare solutions that bridge the gap between conventional medicine and integrative approaches—filling in the blanks that traditional medicine sometimes leaves open.

Recently, this journey brought me an incredible opportunity. I met some of China's top researchers working on Enhanced External Counter Pulsation (EECP)—a cardiovascular therapy that represents exactly the kind of innovative thinking I've grown to appreciate. What caught my attention wasn't just the technology itself, but a breakthrough that Guangzhou Yidian Medical Equipment Co. Ltd. had achieved: they developed the first EECP machine using both positive and negative pressure. While traditional EECP machines rely on single pressure, this dual approach delivers far superior results for patients.

This book tells how China developed its first functional EECP machine and how Guangzhou Yidian took it further with their dual-pressure innovation under Prof. Liang Xiaoming. It's a story that resonates with my own experience—breakthrough solutions often come from people willing to think outside the box. Just like my accounting perspective led me to hormone insights that saved my family, this work in dual-pressure EECP shows how fresh approaches can transform patient care.

What follows covers both the developmental history of EECP and its remarkable range of applications—from treating heart disease and stroke to helping with conditions as diverse as sudden deafness, digestive disorders, and even cerebral palsy in children. You'll discover the science behind how EECP works, its proper applications and limitations, and detailed clinical evidence for treating dozens of different conditions. I hope readers will find the same sense of possibility here that I discovered on my own journey from balance sheets to medical breakthroughs—proof that sometimes the most important discoveries come from unexpected places.

Note: EECP, originally called ECP will be used interchangeably in this book, depending on the context

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Founder, Sumruy Sdn Bhd & AAAIM Sdn Bhd
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Synopsis

Ischemic myopathies, particularly those affecting the heart and brain vessels, are among the most common diseases that threaten human life and health.

The development of External Counterpulsation (ECP), later renamed as Enhanced External Counterpulsation (EECP) has provided a simple, effective, and non-invasive treatment for these conditions. At the same time, EECP serves as an important therapy for health maintenance and recovery.

This book introduces the theory behind EECP, explains its operation procedures, and answers frequently asked questions in plain language. It also contains a comprehensive overview of research and development on EECP both in China and abroad, presenting detailed factual accounts of its progress worldwide.

Author, Prof. Liang Xiaoming, participated in the development of China's first ECP system. With more than 50 years of experience in the field, he has been directly involved in many of the key events that marked milestones in EECP's development. In many ways, this book reflects his personal journey and contributions to the field.

This work is part of the popular science project of the Guangzhou Municipal Technology Bureau (2005). It is intended both as educational reading for patients suffering from ischemic myopathies and as a reference book for medical professionals working with EECP—including doctors, nurses, and technicians—as well as for teachers and students in medical schools who wish to better understand the history of EECP in China.

The materials presented in this book are accurate as of December 2013 and reviewed to 1st Dec, 2025. Because of the wide time span covered, some units of measurement have been preserved in their original form.

Foreword

Enhanced External Counterpulsation (EECP) is a non-invasive physical therapy that integrates pneumatic, electrical, and mechanical technologies to assist human blood circulation through counterpulsation. The fundamental principle involves applying rhythmic pressure to the lower limbs and body during cardiac diastole, thereby reversing arterial blood flow and elevating diastolic pressure. This mechanism improves systemic and coronary circulation, enhances cerebral perfusion, and, by releasing pressure just before the aortic valve opens, reduces cardiac workload and facilitates easier ejection of blood during systole.

The concept of counterpulsation dates back to 1953, when American physician Professor Kantrowitz proposed that increasing diastolic pressure could enhance myocardial and cerebral perfusion, providing therapeutic benefit in coronary artery disease.

In 1968, Professor Soroff, also from the United States, developed the first-generation human-use counterpulsation device. It applied hydraulic pressure to the lower limbs in a non-sequential fashion. Although this innovation demonstrated feasibility, the system was bulky, complex to operate, and yielded unsatisfactory clinical results. By the 1970s, this external approach was largely replaced by invasive intra-aortic balloon counterpulsation (IABP), which gained wider clinical acceptance.

In 1972, researchers in Guangzhou, China, became the first in the country to initiate studies on external counterpulsation (ECP). With support from the Guangdong Provincial and Guangzhou Municipal Science and Technology Committees, the Guangzhou ECP Development Committee was established in 1973, with substantial government funding.

By 1976, China had successfully developed and implemented its first-generation ECP device in clinical practice. In September 1977, the first Chinese clinical paper on ECP, reporting on 32 cases, was published and passed technical appraisal. Two years later, in 1979, the WFB-1 model was launched as China's first commercial ECP product. This model featured sequential four-limb positive-pressure electric valves and pulse-wave monitoring of inflation, marking a major technological milestone. It was officially approved for mass production after passing technical evaluation.

Over the subsequent five decades, EECP research in China has progressed both in depth and breadth. The technology has been introduced into thousands of hospitals nationwide. Investigations evolved from early observational symptom and ECG studies to animal experiments, and later to large-scale clinical trials. Research subjects expanded from healthy volunteers to patients with a wide range of diseases, while study parameters advanced from haemodynamics to haemorheology and microcirculation related to EECP's mechanism of action. These cumulative studies have substantially deepened scientific understanding of EECP's physiological and therapeutic effects.

EECP research that originated in China has since achieved global reach. The field has transitioned from being led solely by medical professionals to involving multidisciplinary

collaborations across research institutions worldwide. In recent years, researchers from technologically advanced countries have become increasingly active in investigating EECP mechanisms and promoting its clinical use.

Chinese-manufactured EECP devices have obtained U.S. FDA approval for market entry. In March 2003, the FDA authorized their use in emergency care and for the treatment of ischemic myopathy. To date, more than 400 medical institutions worldwide have imported ECP devices from China. Clinical evidence demonstrates that, despite the availability of advanced interventions such as coronary artery bypass grafting (CABG), balloon angioplasty, stent implantation, intra-aortic balloon pumping, and hyperbaric oxygen therapy, EECP remains a valuable non-invasive therapeutic option with a steadily expanding user base.

From the late 1980s to mid-1990s, EECP became routine therapy in China, adopted widely across tertiary (“3A”) hospitals and gradually expanding into county-level hospitals and community clinics. Possession of EECP equipment was once considered a hallmark of top-tier medical institutions. Although domestic use later declined due to multiple factors, many hospitals continued to employ EECP, extending its applications to pediatric conditions, including cerebral palsy (in children over four months) and other ischemic neuromuscular disorders.

In recent years, renewed international interest has reinvigorated Chinese EECP research, positioning it as a symbol of modern Chinese medical innovation.

The authors of this book have devoted more than 50 years to EECP research and clinical application, witnessing many of the field’s pivotal milestones and maintaining close collaborations with national experts and engineers. Drawing upon personal experience and the records of eight National EECP Conferences, the authors presented this work as both a comprehensive historical review of EECP’s 50-year development in China and a prelude to the 9th National EECP Conference. Acknowledging the limitations of individual expertise and writing ability, the author sincerely welcomes constructive feedback and academic exchange.

Significant milestones in the internationalization of EECP include:

- 2006 – First International EECP Academic Conference, Guangzhou, China
- October 2009 – Second International EECP Academic Conference
- October 2013 – Third International EECP Academic Conference
- July 2014 – Publication of the *Application Consensus of EECP in Cardiovascular Disease Rehabilitation* in the *Chinese Journal of Internal Medicine* (Vol. 53, No. 7)

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Chapter 1: Chronological Development of External and Enhanced External Counterpulsation (ECP/EECP)

The concept of External Counterpulsation (ECP) originated in the United States. In 1953, Professor Kantrowitz et al. first proposed the principle of phase-shift diastolic augmentation, laying the foundation for future ECP technology.

In 1958, Prof. Kantrowitz and Prof. McKinnon conducted pioneering animal experiments, in which a diaphragm was wrapped around the descending aorta of dogs. Their findings demonstrated a measurable increase in systemic arterial pressure, confirming that external mechanical assistance could augment cardiac output.

In 1962, Prof. Clauss and Prof. Mouloupoulos developed a counterpulsation system based on the withdrawal of blood during ventricular systole through an indwelling arterial cannula, followed by pulsatile reinfusion during diastole. The pump was synchronized using electrocardiographic (ECG) gating, enabling precise timing of systolic withdrawal and diastolic reinfusion. This technique significantly increased the survival rate.

That same year, Prof. Dennis and his team performed counterpulsation experiments in canine models, applying external pressure in synchronization with ECG waveforms. Their results showed that peak diastolic pressure could be increased beyond systolic levels, while left ventricular pressure and the time–pressure product were simultaneously reduced. These findings demonstrated the feasibility of using counterpulsation to enhance coronary perfusion and reduce cardiac workload.

In 1963, Prof. Cacotey became the first to apply external counterpulsation clinically, treating two patients with refractory angina pectoris. Both cases reported marked symptomatic improvement, providing early human validation of ECP's therapeutic potential.

By 1967, internal counterpulsation had entered clinical use for acute myocardial infarction complicated by cardiogenic shock, and for low-output syndromes following open-heart surgery. Favorable results were also observed in refractory angina patients prior to infarction, reinforcing counterpulsation's value as an assistive circulatory therapy.

In 1968, Prof. Soroff et al. designed and manufactured the first batch of ECP devices for human use. The apparatus consisted of rigid, airtight chambers enclosing the lower limbs, surrounded by water-filled balloons and sealed with airtight covers. A vacuum pump was used to generate negative pressure, while positive pressure up to 200–250 mmHg (1 mmHg = 133.22 Pa) was applied during diastole in synchronization with ECG signals. The objective was to force arterial blood from the lower limbs toward the central arteries, thereby increasing diastolic arterial pressure, reducing afterload, and improving coronary flow.

However, the device was bulky and complex, and no significant increase in diastolic pressure was observed during clinical trials. Consequently, this early design was deemed unsatisfactory.

In 1973, Prof. Cohen compared sequential and non-sequential pulsation modes in seven healthy patients. The sequential inflation pattern—beginning with the calves and progressing to the thighs and buttocks—proved more physiologically effective. This innovation became the prototype of Enhanced External Counterpulsation (EECP), distinguishing it from earlier non-sequential ECP systems.

In 1974, Prof. Harry, Prof. Scoff et al. reported clinical results using early EECP models in 20 patients with a history of heart disease who subsequently developed cardiogenic shock.

By 1976, China had entered the field of ECP development. The Guangzhou ECP Development Committee, headed by the Guangzhou Medical Appliance Factory (Mr. Che Songzhao) and co-led by Zhongshan Medical College of Guangzhou (Prof. Zheng Zhensheng) and Medical Appliances Factory of Guangzhou (Mr. Zhang Yangzhong), successfully created the FB-2A ECP system (available in both internal and external models). The external version introduced sequential four-limb positive-pressure valve technology, enabling real-time monitoring and adjustment through fingertip blood pressure feedback—a significant technological advancement.

On September 26, 1977, the FB-2A system passed official technical appraisal, and the committee published China's first clinical thesis on ECP, documenting 32 patient cases.

On September 22, 1979, the Guangzhou Electrical Appliance Factory began mass production of ECP devices. The first-generation WFB-1 model employed sequential four-limb positive-pressure valves, passed production appraisal, and received approval for clinical use. These systems represent the earliest domestically produced ECP devices in China, marking a major milestone in the nation's medical device innovation.

In 1980, Prof. Zheng Zhensheng and Prof. Deng Zhaowen of Zhongshan Medical College published the paper Clinical Observation of the Effectiveness of Sequential Four-Limb Positive Pressure ECP in 36 Cases of Acute Myocardial Infarction. Around the same period, Prof. Zheng Zhensheng and Prof. Ma Hong reported Preliminary Observation on the Haemodynamics Following Sequential Four-Limb Positive Pressure ECP in Myocardial Infarction, describing significant haemodynamic improvements in most cases, except one patient with a fused right coronary catheter.

On June 24, 1982, Guangzhou Medical Appliance Factory, in collaboration with Zhongshan Medical College, successfully developed China's first enhanced pulsed-pressure EECP device, integrating four-limb and buttock cuffs. This second-generation model, designated WFB-II B, passed official technical appraisal and entered production under the formal name Enhanced External Counterpulsation (EECP) — marking the first appearance of the term in China's medical device registry.

In December 1984, Zhao Guanlin of Shanghai published a pivotal article titled Comparative Observation of the Effectiveness of EECP and Medical Treatment on Angina Cordis in China Angiocardiopathy Journal (Vol. 12, Issue 4). This was the first EECP-related paper ever published in that journal and concluded that EECP treatment was more effective than conventional pharmacological treatment alone.

In 1986, Prof. Sun Jichuan, Prof. Wang Shichen, and Prof. Tian Haiqing from Xi'an Medical University Hospital Number 2 published Changes in Haemodynamics When EECP is Applied — A Study and Observation of 15 Cases of Cardiac Bi-Catheter Application. The study reported that EECP increased diastolic-phase pressure (distinct from diastolic blood pressure) while lowering end-diastolic pressure. When positive pressure was used, end-diastolic pressure rose slightly, whereas negative pressure produced a mild decrease. During the first 15 minutes of EECP, cardiac output increased, but stabilized thereafter. In patients without severe cardiac insufficiency, no significant rise in venous return was observed, while pulmonary capillary pressure decreased slightly. This **precise balance between positive and negative pressure modulation distinguished their research from contemporaneous studies.**

Over the following decade, researchers conducted nearly one hundred cardiac bi-catheter monitoring studies, comparing pre-, intra-, and post-EECP haemodynamics. These investigations expanded to examine EECP's influence on haemorheology, free-radical metabolism, lipid peroxidation, endothelial cytoplasmic repair, cell membrane adhesion, insulin receptor activity, and ion channel regulation (potassium, sodium, and calcium).

In 1986, studies further revealed that prior to EECP, the ear pulse-wave and the onset of the mid-diastolic wave lagged behind the aortic diastolic wave by approximately 20 milliseconds. When EECP was applied, this lag increased to an average of 50 milliseconds, suggesting enhanced peripheral pulse transmission delay due to counterpulsation dynamics.

In 1987, Prof. Liang Xiaoming proposed employing negative-pressure discharge to enhance decompression efficiency, effectively reducing systolic workload on the heart and resolving longstanding issues in positive-pressure EECP systems — such as slow discharge speed, incomplete deflation, and recurring mechanical failures. This led to the **patenting of a positive-negative air pressure circulatory EECP system**, marking a technological leap in device engineering.

Also in 1987, Prof. Song Youcheng, Prof. Zhang Kuaijun, Prof. Liu Lisheng, and Prof. Tao Shouqi of Beijing Fuwai Hospital published Monitoring Research on the Internal Pressure of the Radial Artery During EECP in 10 Patients in China Circulation Journal (Issue 4, p. 462).

On December 8, 1987, the Editorial Committee of the journal “China External Counterpulsation” was officially established in Zhuhai, China, providing the country with its first dedicated publication platform for ECP research.

In 1988, Prof. Hu Jianwu of Shanghai published Two Comparative Case Studies of Coronary Artery Opacification Before and After EECP Treatment in Coronary Heart Disease. The findings demonstrated significant collateral circulation formation, marking the first Chinese study to use angiographic opacification to evaluate EECP efficacy.

That same year, Prof. Wu Shuyan, Prof. Xu Yuyun, Prof. Wang Lihui, and Prof. Zhu Guoying of Beijing Medical University Hospital Number 1 reported Using ^{201}Tl Myocardial Perfusion Imaging and Target Heart Rate to Evaluate EECP in Angina Pectoris. Among 21 patients (10 controls), EECP yielded notable clinical and imaging improvements.

Also in 1988, Prof. Gao Surong and Prof. Shen Peiyao of Beijing Medical University Hospital Number 1 published Using EECP to Treat Transient Cerebral Ischemia: A Single Photon Emission Computed Tomography (SPECT) Study of 18 Cases in China External Counterpulsation (Vol. 2, 1989), confirming improved cerebral perfusion after EECP.

Meanwhile, Prof. Lun Zhan and Prof. Gao Chongxuan of the China National Sports Research Center, in collaboration with Prof. Liang Xiaoming, explored EECP's application in reducing sports fatigue, also published in China External Counterpulsation (1988). This marked one of the earliest non-cardiac applications of EECP.

In early 1989, Prof. Liang Xiaoming, Prof. Ji Jihua, Prof. Xu Zhongbang, and Prof. Bu Jiajun began developing China's first EECP device for pediatric use, which was subsequently implemented clinically at Nanjing Medical College Hospital Number 2.

By 1992, this line of work produced the first Chinese publication on the use of EECP for treating cerebral palsy.

In 1989, Prof. Zhao Guanlin and Prof. Zhu Junjie of Shanghai published A Study on the Effectiveness of EECP in Improving Regional Cerebral Ischemia — A CT-Based Study of 44 Cases (22 controls). The results showed significant superiority of EECP treatment over controls ($X^2= 7.78$, $P < 0.01$). The study appeared in China External Counterpulsation (Vol. 1, Issue 3, 1990) and was later reprinted in the first issue of Shanghai Textile Medical Science (1994).

In 1990, Dr. Xu Jiali of the Hubei Medical College Hospital Number 1 conducted an experiment on patients who underwent PTCA and had suffered from angina pectoris showed that EECP had significant improvements.

In 1990, Prof. Du Hujun and Prof. Huang Dingjiu of Shanghai Renji Hospital completed research on The Effect on Haemodynamics of Coronary Artery Disease Patients with EECP on 16 patients with reports on flow guided catheter and arterial radialis pressure.

In 1991, China Angiocardiopathy Journal Volume 19 Issue 4 page 283, Prof. Song Youcheng, Prof. Zhu Jun and Prof. Liu Yunzhong of Beijing Fuwai Hospital published Using ^{201}Tl Myocardial Perfusion Imaging to Evaluate the Clinical Effectiveness of EECP on Coronary Disease and Angina Pectoris.

Between 1986 and 1992, Prof. Hu Jianwu coordinated a joint effort with:

1. Xi'an Medical University
2. Beijing Fuwai Hospital
3. Shanghai Medical University
4. Shanghai Institute of Angiocardiopathy
5. Shanghai Renji Medical University Hospital Number 2
6. Chongqing Medical University

to standardize the EECP device model WFB and design requirements.

They worked together to complete 134 cases of right heart Swan-Ganz catheter experiments to examine coronary disease patients' haemodynamics before, during, and after EECP. At the same time, artery diastolic pressure at the radial artery was measured. All results showed that the EECP device model WFB is the safe and preferred choice.

In June 1992, Prof. Zhao published in the 4th issue of China External Counter Pulsation Journal a thesis titled Using Pulsed Doppler Echocardiography in a Quantitative Measurement of the Blood Flow Changes in the Main Artery When Using EECP on 39 Patients.

When using EECP, there was significant improvement in the stroke volume of the common carotid artery, blood flow per minute, and diastolic period peak speed compared to before EECP was applied ($p < 0.001$), of which in 33 patients the stroke volume of the common carotid artery increased by an average of 17.78%. This was the first-ever research on the effects of EECP on the human common carotid artery in the world.

In 1993, Prof. Wu Shenyong and Prof. Zhao Keshen of Guangzhou Military Medical University Number 1 published The Clinical Effectiveness of EECP on Dogs' Circulatory Disturbance Caused by Haemorrhagic Shock.

Since 1995, EECP devices have been exported to America, Europe, Japan, Macau, Hong Kong, Africa, Southeast Asia, and Russia. Statistics in 2013 reported that six models of EECP devices from several Chinese factories had been authenticated by the FDA. More than 500 EECP devices have been exported to America, and American insurance companies have included EECP treatment in their policies.

In 1996, at the 6th National External Counterpulsation Conference, Prof. Zhao Guanlin reported his observation: during two sets of EECP treatments in 13 patients with ischemic acute shock, EECP affected their levels of ferritin and renin-angiotensin II.

- In 12 patients, there was a decrease in ET ($P < 0.05$)
- In 9 patients, ferritin decreased ($P > 0.05$)
- In 9 cases, renin-angiotensin decreased ($P > 0.05$).

This was reported both domestically and internationally.

In 1984, the China External Counterpulsation Committee was established. On December 5, 1987, the ECP Development Center of China Medical Apparatus and Instrument Company was established. Up till July 2004, eight national EECP conferences had been held in China to summarize and promote EECP technology. The 9th EECP Conference was held in 2006. By 1996, there were more than 6,000 EECP devices being used in over 4,000 Chinese medical institutions. In Guangzhou, Beijing, and Shanghai, the ratio was one EECP device per 40,000 citizens.

In 2000, Prof. Wu Li and Prof. Wu Wei reported the effect of EECP devices on three coronary disease patients, with three sets of treatments affecting the level of renin-angiotensin.

From 2000 onward, Prof. Chen Yunzhen and Prof. Luo Yufeng of Chongqing Medical University conducted research on more than 50 cases of coronary artery bypass and stent implantation patients. The experiments showed that EECP had a positive effect on all patients, with results published in the *Chongqing Medical University Journal*.

Researchers in the United States and other countries, influenced by Chinese research in the mid- and late-1990s, adopted standardized methods using nuclear angiocardigraphy, and quantitative analyses to verify EECP's effectiveness in ischemic heart disease. Their findings concluded: EECP is safe and effective; its effectiveness can reach 95% for single-condition heart disease, 90% for dual, and 41% for triple disorders. EECP was also shown to help prevent restenosis after PTCA and serve as a non-invasive adjunct treatment for intractable angina.

In 2001, at the American Heart Association Annual Conference, Tokyo University presented that EECP relieves chest pain by promoting the release of vascular growth factors.

In 2002, five U.S. universities — Harvard, Yale, Columbia, the University of California San Francisco, and the State University of New York — published research supporting EECP for coronary heart disease.

In 2003, Prof. Lu Li, Prof. Wu Weikang, and Prof. Zheng Zhensheng reported on animal research showing how protein kinase C prevents myocardial ischemia.

In March 2003, the U.S. FDA authorized EECP for use in treating cardiac shock, acute myocardial infarction, and angina pectoris.

Encouraged by international recognition, Chinese researchers advanced EECP further. The 7th National EECP Conference was held in Wuyi Mountain in July 2002, followed by the 8th in Guangzhou (July 2004) and a provincial conference organized by Sichuan Medical Association in Chengdu (July 29, 2005).

2005–2009

Clinical trials and heart-failure interest

Controlled and single-arm studies demonstrated that EECP improves exercise tolerance and symptoms in selected patients with chronic heart failure and refractory angina. These findings expanded EECP's use beyond "angina salvage" toward cardiac rehabilitation.

Mechanistic research intensifies

Animal and human studies focused on shear-stress-mediated endothelial changes (nitric oxide, prostacyclin / prostaglandin I₂), reduced platelet activation, and early evidence of collateral vessel recruitment.

2010–2013

Randomized and sham-controlled studies

High-quality small Randomized Controlled Trials (RCTs) (including sham-controlled trials) showed that EECP enhances endothelial function (e.g., flow-mediated dilation) and improves surrogate biomarkers such as nitric oxide and inflammatory markers, strengthening mechanistic validity.

Guideline recognition

Major cardiology guideline committees (ACC/ESC) began acknowledging EECP as a second-line or adjunctive therapy for refractory or stable angina (Class IIb recommendation), noting clinical benefit for selected patients while emphasizing the need for more large-scale RCTs.

2014–2017

Meta-analyses and registry data

Systematic reviews and large registry analyses confirmed that EECP reduces anginal episodes, increases exercise duration, and improves quality-of-life scores in refractory angina, though study heterogeneity remained a limitation.

Device ergonomics and protocol refinement

Manufacturers improved timing algorithms, monitoring metrics (D/S and area ratios), balloon geometry, and safety interlocks. Active negative-pressure deflation systems gained attention for enabling faster and more complete deflation and improved afterload reduction.

2018–2020

Expansion into non-cardiac applications

Clinical reports and small series explored EECP for cerebrovascular ischemia (stroke recovery, chronic cerebral hypoperfusion), ophthalmic ischemic disorders (retinal and optic nerve ischemia), and peripheral arterial disease, showing promising but preliminary outcomes.

Biological mechanisms better characterized

Studies identified long-term vascular effects following EECP, including increased circulating endothelial progenitor cells (EPCs), favorable modulation of inflammatory cytokines, and sustained endothelial function improvement.

2020–2022 (COVID era)

Research slowdown with continued analysis

The pandemic slowed large multicenter trials but mechanistic and registry analyses continued. EECP remained of interest as a non-invasive therapy to enhance perfusion in chronic ischemic conditions. Concepts of remote or ambulatory EECP monitoring began to emerge.

2023–2025

Refinement, personalization, and hybrid integration

New trends include integrating EECP into multimodal cardiac rehabilitation (combining EECP, exercise, and risk-factor management), tailoring therapy parameters to patient hemodynamics, and expanding use in neurological rehabilitation (stroke, cerebral palsy sequelae).

Device advancement

Next-generation systems feature greater portability, improved ECG/pulse synchronization, enhanced user interfaces, real-time oximetry, and advanced safety monitoring. Compact designs and negative-pressure deflation units became increasingly suitable for outpatient and rehabilitation settings.

Evidence gap remains

By 2025, EECP shows consistent symptomatic benefit for refractory angina and measurable endothelial improvements. However, high-quality, large-scale trials for non-cardiac indications (stroke, ocular, renal ischemia) remain limited, leaving EECP as a valuable adjunctive—rather than universal—therapy.

Summary

From 2005 to 2025, EECP evolved from an adjunctive symptomatic therapy for refractory angina into a well-characterized vascular modulation treatment with proven endothelial, hemorheologic, and symptomatic benefits. Device technology has matured—achieving faster deflation, better synchronization, and patient-specific adaptability—while clinical use has expanded into cardiac and neurovascular rehabilitation programs. Despite its progress, the need for large, definitive randomized studies continues, keeping EECP positioned as a *trusted adjunctive therapy* rather than a mainstream primary intervention.

We believe EECP has the potential to make a greater impact in the foreseeable future on cardiovascular diseases.

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Appendix V: Frequently Asked Questions

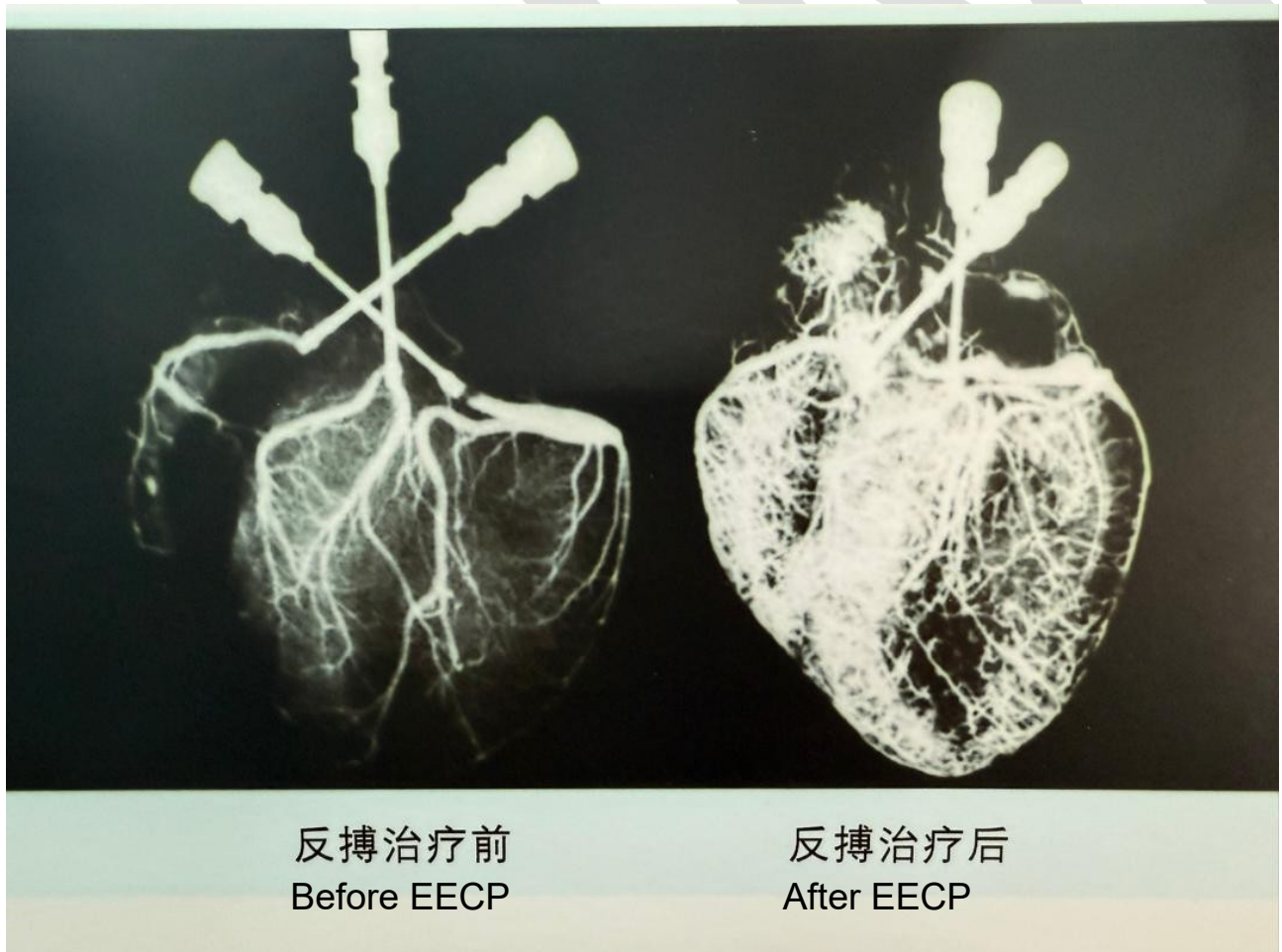
1. What is EECP?

Enhanced External Counterpulsation (EECP) is a non-invasive therapy designed to improve blood flow to the heart and relieve symptoms of angina (chest pain) or heart failure.

During EECP, inflatable cuffs are wrapped around the patient's calves, thighs, and buttocks. These cuffs inflate and deflate in synchronization with the patient's heartbeat, timed by an electrocardiogram (ECG).

- Inflation during diastole (heart relaxation): pushes blood back toward the heart, increasing coronary perfusion and oxygen supply to the myocardium.
- Deflation just before systole (heart contraction): reduces vascular resistance and cardiac workload.

EECP enhances collateral circulation, improves endothelial function, and may help develop natural bypasses in the coronary arteries over time.



Various studies have been done since its inventions and upgrades showing beneficial results especially for cardiac blockages.

The above pictures of before and after EECP shows extensive alternative vessels were created with over 30 hourly EECP sessions.

2. Besides EECP, there is also the intra-aortic counterpulsation. What is it?

Intra-Aortic Balloon Pump (IABP) is a form of invasive counterpulsation therapy that provides temporary mechanical circulatory support in patients with severe cardiac dysfunction.

A balloon-tipped catheter (≈40 mL) is inserted via the femoral artery and positioned in the thoracic aorta just below the origin of the left subclavian artery.

- During diastole, the balloon inflates with gas (helium or carbon dioxide), displacing blood toward both the aortic root and distal aorta, which increases coronary perfusion pressure and diastolic aortic pressure.
- Just before systole, the balloon rapidly deflates, reducing afterload and decreasing myocardial oxygen demand.

Thus, IABP works by improving oxygen supply to the heart while simultaneously reducing its workload — following the same physiological principle as EECP, but performed internally within the aorta.

3. How is EECP and IABP different in terms of the pros and cons?

EECP (Enhanced External Counterpulsation) - Pros:

- Non-invasive, safe, and suitable for long-term or repeated use
- Can be done on an outpatient basis
- **Improves coronary perfusion and collateral circulation gradually**
- Few complications and relatively low cost

EECP (Enhanced External Counterpulsation) - Cons:

- Indirect and weaker hemodynamic effect
- Not suitable for acute or emergency cardiac support

IABP (Intra-Aortic Balloon Pump) - Pros:

- Direct action in the aortic root → stronger counterpulsation effect
- Provides rapid, effective hemodynamic support in acute cases
- Reduces cardiac workload and improves coronary perfusion efficiently

IABP (Intra-Aortic Balloon Pump) - Cons:

- **Invasive procedure with risk of bleeding, infection, or vascular injury**
- **Unsuitable for long-term or repeated use**
- **Technically demanding and costly**
- **Limited indications** (mainly acute or critical cardiac conditions)

In summary, EECP is non-invasive and best for chronic stable cases, while IABP is

invasive but provides strong, immediate support in acute cardiac emergencies.

4. What are the benefits of EECP?

The benefits of Enhanced External Counterpulsation (EECP) can be understood through its counterpulsation effects, efficacy, and net benefit.

During EECP, rhythmic inflation and deflation of the cuffs create physiological changes known as counterpulsation effects—including increased diastolic pressure, improved coronary perfusion, reduced cardiac workload, and better oxygen delivery. These effects can be observed through indicators such as the D/S ratio and DP/SP ratio on arterial waveforms, which reflect improved hemodynamics during treatment.

Over time, these effects translate into therapeutic efficacy—the actual improvement in clinical symptoms, such as **reduced angina, enhanced exercise tolerance, and better cardiac function**. However, efficacy depends on factors such as patient selection, device performance, and accuracy of operation. A strong physiological effect does not always guarantee better clinical outcomes if synchronization or case suitability is poor.

EECP also has a net benefit, meaning the overall positive outcome after balancing benefits and side effects. While it can **increase venous return and oxygen consumption**, the therapy typically boosts oxygen supply even more—resulting in a favorable overall effect. Minor issues like skin irritation may occur but are manageable.

In summary, EECP offers meaningful cardiovascular and systemic benefits by improving blood flow, reducing cardiac strain, and enhancing heart efficiency—provided it is performed correctly, with validated equipment and proper patient selection.

5. Does EECP require negative-pressure deflation?

Yes. There are two types of EECP:

- 1) Most abundant EECPs are just the positive type pressure and usually require 35 or more hourly sessions to achieve desired results;
- 2) **Positive and Negative Pressure deflation.**

Using negative pressure suction during deflation greatly improves speed and completeness of air evacuation before systole, proven by comparative data. See pages 107-109 “EECP Clinical Effect: Positive-Negative Pressure vs Positive Pressure”.

From a layman perspective, a Positive Pressure Type EECP is equivalent to a boxer landing multiple punches repetitively without sufficient retraction vs Positive-Negative Pressure Deflation EECP which allows for complete and faster deflation in between punches. With Negative Pressure actively sucking cuffs air, this allows each punch similar to the first punch with maximum impact.

The Positive-Negative EECP pressure deflation explained in detail on pages 107-109

shows more pronounced improvements compared to just Positive Type EECP. In short, **Positive Negative Type does more with less** vs Positive Pressure Type.

6. What is the difference between foldable and non-foldable EECP machines?

Foldable EECP machines are designed for portability, space-saving, and improved aesthetics, making them easier to store or move between locations. However, to achieve a foldable design, the inflation–deflation pump must be made smaller, which reduces the air pressure and flow capacity available during treatment.

As a result, while foldable machines are more convenient and compact, their therapeutic effect and hemodynamic efficiency are generally weaker compared to **non-foldable (standard) EECP systems, which use larger pumps capable of delivering stronger and more consistent counterpulsation pressure.**

So don't be simply impressed and awed by newer more sophisticated models.

Substance over Form was what matters. Effective with the minimal sessions rather than having more EECP sessions to get desired results.

7. Does using advanced technology or new patents and developments guarantee better performance?

Not necessarily. It depends on what new technology is implemented. For example:

- The WFB-IIB EECP, made in the early 1980s without computer control (manual inflation/deflation timing), remains highly praised after 20+ years for its safety, reliability, and therapeutic effect.
- Automated synchronization may not necessarily outperform semi-automatic systems.
- Some advanced foreign intra-aortic systems in the 1970s still used manual controls, yet achieved reliable outcomes.

Similarly, changing from a single-chamber cuff to a three-fold cuff may reduce size and air volume slightly but, if the effective area becomes too small, performance worsens. Compact, “integrated” designs that at the expense of functional effectiveness are considered poor engineering tradeoffs. Only through scientific, comparative testing can one conclude true performance differences.

8. What countries are producing EECP machines with both Positive and Negative pressure?

The EECP machines are manufactured mainly in China, United States and India. By now there should be more Countries manufacturing EECP. Readers are encouraged to do their own research to decide the most suitable EECP with sufficient backups and maintenance.

Any proven fact checked updates are welcomed; email sumrui@gmail.com

Appendix VI: Pictures of EECP Pioneers



Prof Liang Xiaoming was awarded by the Health Minister for his contribution to the EECP Research.
August 1990



Prof. Liang Xiaoming with Chairman of International EECP at the Symposium.
May 14, 2006



Prof. Liang Xiaoming met Prof. Soroff who developed the first ECP.
August 6, 2005 in Guangzhou.



Prof. Liang Xiaoming taking a picture with the Chairman of International ECP Symposium, Prof Zheng Zhenshen. May 14, 2006

Sun Yat-Sen Hospital 1 Cardiologist Dr Du Zhimin and Toh Sek Cheong (Malaysia). 2012



Prof. Liang Xiaoming with Prof. Zhen Zhengsheng who are the pioneers of EECF.



Toh Sek Cheong and Toh Phang Sum with EECP doctors and nurses at Sun Yat-Sen Hospital 1, Guangzhou, 2018.

Conclusion

In summary, EECP, as a non-invasive and non-physical treatment, provides protection for the heart, enhances tolerance to physical exercise, and improves patient safety during treatment. Additionally, EECP strengthens overall cardiac function and optimizes the patient's physiological and pathological condition. Patients who undergo EECP often experience better outcomes when continuing with subsequent medical treatments and exercise programs, contributing significantly to treatment compliance and clinical benefits. Further clinical research and evaluation are needed to determine how best to integrate EECP with other cardiovascular disease treatments to achieve maximum therapeutic synergy.

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