

HEALTHY LONGEVITY GLOBAL COMPETITION

2023 Catalyst Awardees

Sponsor: Chinese Academy of Medical Sciences

A High-sensitive Lung Cancer Screening Breath Analysis System Based on Separation-Sensing

Principal Investigator	Meixiu Sun , PhD
PI Primary Affiliation	Institute of Biomedical Engineering ,Chinese Academy of Medical Sciences
Co-Investigator(s)	Xunming Ji, MD, PhD; Miaowen Jiang, PhD; Zhichen Yin, PhD

PROJECT DESCRIPTION

Effective screening methods have the potential to enhance the survival rate among individuals diagnosed with lung cancer. Notably, breath analysis offers several advantages, including its non-invasive nature, real-time results, and simplicity. Currently, research on breath markers for lung cancer is progressing rapidly towards clinical implementation. Nevertheless, the existing mass spectrometry technology is both expensive and cumbersome, necessitating approximately 10 hours of vacuum preparation and specialized expertise for operation. In contrast, cavity ringdown spectroscopy (CRDS) presents a portable, cost-effective, and user-friendly alternative. However, the detection accuracy of hypertrace lung cancer marker gas is hindered by the interference of non-detection gas spectral interference. To address this issue, it is suggested to enhance the selectivity of CRDS technology by integrating it with gas separation membrane technology. This integration aims to develop a lung cancer screening breath analysis system that is characterized by high precision, stability, and integration. This objective will be achieved through the implementation of six module solutions and an integrated control design.

A Novel Anterior Pelvic Ring Fixation System for Fragile Pelvic Fracture: Development and Biomechanical Study

Principal Investigator	Yonghui Liang, Professor
PI Primary Affiliation	Aerospace Center Hospital
Co-Investigator(s)	Chen Fei, MD Zhao Zhengang, MD Wang Haishan, Bachelor Degree Sun Danzhong, Bachelor Degree Xiao Zhenxin, Master Degree

PROJECT DESCRIPTION

With the aging of human society and the more active lifestyles of the elderly, the number of patients with pelvic fractures is rising annually. While posterior ring fixation techniques have shown significant progress as minimally invasive techniques developed, optimal method for anterior ring fixation is still controversial. The widely used INFIX system, which applies spinal screws directly to the anterior pelvic ring, has shortcomings related to mechanical requirements, application scenarios and anatomical characteristics. Our preliminary studies identified the main causes for the complications of INFIX including: 1. The thread of the screw designed for the spine is not suitable for the pelvic bone and its length is insufficient, which leads to the loosening of the screw and limits its

application; 2. The integrity of the screw tail and screw is not suitable for early removal and thus limits the application of bone cement reinforcement for fragility fractures; 3. Excessive notches and straight screw design make the skin and lateral femoral nerves irritable, causing obvious local pain. To address above limitations, we designed four new type of internal fixation screw systems , each with its advantages in terms of strength and convenient operation. However, their mechanical stability and clinical applicability require further investigation. Therefore, we designed " A Novel Anterior Pelvic Ring Fixation System for Fragile Pelvic Fracture: Development and Biomechanical Study". We aim to identify the optimal screw fixation for the pelvic anterior ring through finite element analysis and biomechanical experiments, with the goal of enabling industrial production.

A Novel in situ Coronary Photo-cross linking Natural Vascular Scaffold (NVS) System

Principal Investigator	Chen Han, PhD
PI Primary Affiliation	Zhongshan Hospital
Co-Investigator(s)	Rongping Dai , MD; Youxin Chen,MD; Zhikun Yang,MD; Jingyuan Yang, MD

PROJECT DESCRIPTION

Coronary artery disease (CAD) is a major cause of global disease-related deaths, posing significant challenges to public health. Although drug-eluting stents have reduced restenosis rates, long-term use can lead to neointimal hyperplasia and restricted blood vessel movement. In response, the "Leave Nothing Behind" approach has emerged as a new direction in coronary intervention. However, current options like biodegradable stents and drug-coated balloons have limitations.

To address these shortcomings, we propose inducing collagen fiber cross-linking after vascular dilation to create an in-situ natural vascular scaffold (NVS). The irregular mesh-like arrangement of collagen fibers within the extracellular matrix allows the NVS to slow down drug release and maximize the effectiveness of anti-proliferative drugs, avoiding immediate stenosis while promoting vascular repair.

Our preliminary research involved the development of lysine-arginine dendrimeric photosensitive intelligent materials (NIPD) that mimic collagen fibers. We verified their safety and cross-linking effectiveness on vascular tissues. Through an NIPD-coated NVS system with an embedded optical fiber, we demonstrated feasibility in small pig peripheral blood vessels.

Next, we plan to validate the feasibility and effectiveness of NIPD-NVS in large animal models of coronary artery injury while conducting mechanistic studies. Additionally, we aim to optimize the NVS system by incorporating paclitaxel drug coatings, providing robust support and repair capabilities to damaged blood vessels.

By addressing the technical limitations of existing interventions, our project aims to achieve natural vascular repair without the need for permanent implants. This research has the potential to revolutionize the prevention and treatment of common cardiovascular diseases.

Analysis of tumor molecular profile in older patients and its clinical application in diagnosis and treatment

Principal Investigator	Wenbin Li, PhD
PI Primary Affiliation	National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College
Co-Investigator(s)	Yuxiang Zhi, MD; Nan Zhou, BS; Yisen Yang, BS; Yaoyu Hu, BS; Shuanzheng Zhao, BS

PROJECT DESCRIPTION

Older adults are a high-risk population for malignant tumors, often accompanied by organ function decline and various comorbidities. They have a shorter survival period and poorer prognosis. There are differences between older and younger patients in terms of the distribution of tumor histological subtypes and molecular variations. The identification of potential beneficiaries among older patients for targeted therapy, evaluation of treatment risks and expected outcomes, and the development of precise individualized treatment plans are urgent tasks in dealing with elderly cancer patients. In this study, cancer patients were collected from the National Cancer Center/Cancer Hospital, Chinese Academy of Medical Sciences, between 2013 and 2023, and advanced techniques such as multiplex immunofluorescence and next-generation sequencing were used to analyze the genomic mutation spectrum characteristics of elderly solid tumor patients. A molecular subtype with prognostic significance was constructed by combining patient clinical prognostic information, aiming to explore the similarities and differences between the elderly population in China and younger patients in terms of pathological characteristics, molecular phenotypes, and prognostic factors in common tumors (lung cancer, breast cancer, and colorectal cancer). This research aims to assist clinicians in providing more rational personalized treatment plans and improving the prognosis of elderly cancer patients.

Clinical translational study of suprachoroidal indentation balloon and implantation device in macular area of high myopia

Principal Investigator	Huan Chen, MD
PI Primary Affiliation	Peking Union Medical College Hospital, Chinese Academy of Medical Sciences
Co-Investigator(s)	Ming Liu , PhD; Min Chen, Phd; Chunmei Li, Phd; Wei Zhang, Phd; Wen Zhen, Phd; Mengxiao Peng; Phd Candidate; Menglin WU, PhD; Shiping Zhang, MS; Han LI; Longteng Liu, PhD; Wenrui Xu, Phd; Tongzheng Lu, MS; Haoran Wang, MS; Wen Liu, MS; Jiening Wang, MS.

PROJECT DESCRIPTION

High myopic maculopathies have become one of the main causes of blindness in adults at present. Current surgical procedures include vitrectomy and posterior scleral reinforcement, however, they both had limitations and problems , such as severe surgical complications, limited source of materials and ethical issues. Therefore, our team innovatively invented a suprachoroidal indentation balloon and its implantation device, with the purpose of shortening the eyeball and treating maculopathy by pressing the suprachoroid space of macular region in high myopia. At present, the relevant patents have been applied, and sample diagram of the device has been completed. In the preliminary animal experiments, local retinal indentation was achieved by injecting a pressurized sponge and viscoelastic into the suprachoroidal space. This project intends to complete the prototype of the novel suprachoroidal indentation balloon and its implantation device, to demonstrate its effectiveness (shortening of axial length) and safety (postoperative inflammation) in bred rabbits,so as to provide a solid research foundation for clinical validation in the future.

Construction and application of an efficient circulating tumor cell detection system based on magnetic cell probes

Principal Investigator	Fan Zhang, PhD
PI Primary Affiliation	Institute of Biomedical Engineering, Chinese Academy of Medical Sciences, Peking Union Medical College
Co-Investigator(s)	Tengfei Ji, PhD; Haiguang Yang; Peng Ma; Zijing Wang; Tianshu Xu; Tingting Zhu; Siyuan Zhang

PROJECT DESCRIPTION

Circulating tumor cells (CTCs) testing is important for the early diagnosis and treatment of cancer. However, in clinical application, the CTCs amount in blood is very low, the sample demand is large, the detection time is long, the epithelial-interstitial transition, the non-specific adsorption of white blood cells, and the cell loss is serious, which cannot meet the requirements of efficient sorting, enrichment, detection and analysis of CTCs.

In this project, Fe₃O₄ nanoclusters were phagocytized by monocytes which expressing epithelial cell adhesion molecule (EpCAM) and cell surface vimentin. And the magnetic cells targeting EpCAM and CSV antigens were prepared for capture circulating tumor cells. By combining magnetic cells with high-throughput microfluidic chips to construct an efficient circulating tumor cell detection system, CTCs detection and analysis with low sample size, simple operation, low adsorption of white blood cells and maintenance of cell activity can be realized efficiently. We would investigate the effect of the detection system on capturing simulated blood samples and CTCs in blood samples. By optimizing the preparation technology and detection scheme, it would obtain an efficient circulating tumor cell detection system based on magnetic cell probe, realize the capture of CTCs with low sample size, simple operation, high throughput, low adsorption white blood cells and high activity. This work would provide theoretical basis and experimental support for the capture, detection, culture and analysis technology of CTCs in scientific research and clinical practice.

Development and commercialization of nitric oxide therapeutic devices

Principal Investigator	Tianshu Chu, PhD
PI Primary Affiliation	The First Hospital Affiliated of USTC Anhui Provincial Hospital
Co-Investigator(s)	Maigeng Zhou, PhD Yamin Bai, PhD Peng Yin, PhD Kai Xing, PhD Jie Zheng, PhD Jia Wang, MD You Lv, MD Min Dong, MD Yuqing Tian, MD Suijun Tong, MD Rui Wang, MD Donghao Liu, MD

PROJECT DESCRIPTION

Inhaled Nitric Oxide can be used to treat a variety of conditions including pulmonary hypertension and respiratory failure, however, inhaled Nitric Oxide therapy requires the use of specialized device. Inhaled nitric oxide therapy was initially applied to critically ill neonates with pulmonary hypertension who were connected to a ventilator, and was later expanded to critically ill adults, however, a large number of clinical practices and studies have found that it is also effective in patients who are not connected to a ventilator. The project team has verified the safety and effectiveness of "In heaven" technology in multi-scenario inhalation nitric oxide therapeutic device through clinical research, and developed the Oxygen Mixing Inhalation Nitric Oxide device based on the "In heaven" technology. Based on the "In heaven" technology, we have developed three medical devices: oxygen mixing inhalation nitric oxide controller, direct inhalation nitric oxide device and pulse nitric oxide device.

Development and dissemination of an artificial intelligence-assisted assessment system for cardiotoxicity of immunotherapy in elderly oncology patients

Principal Investigator	Leilei Cheng, MD, PhD
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PI Primary Affiliation	Zhongshan Hospital, Fudan University
Co-Investigator(s)	Jianqun Gao, PhD; Tifei Yuan, PhD; Qi Liu, PhD; Qi Cheng, PhD; Yue Yang, PhD; Guangfu Wu, PhD

PROJECT DESCRIPTION

China's elderly population is increasing rapidly, and the incidence of cancer is much higher than that of young people. It is expected that the population over 69 years old will exceed 400 million in 2035, accounting for more than 30% of the population, posing significant medical challenges. Immune checkpoint inhibitors (ICIs) have achieved great success in cancer treatment, but ICI-related myocarditis is a serious side effect, with an incidence rate of 1.14% and a mortality rate as high as 66%, which is particularly dangerous. Additionally, elderly patients may not only "have a tumor" but also "have it in their heart." In order to meet the needs of elderly Chinese oncology patients, the project has established a multidisciplinary joint clinic, and the "ICIs Myocarditis Online Assessment Applet," developed with AI technology, has been trialed in many hospitals to aid in early identification, accurate staging, and standardized treatment. By promoting the multidisciplinary joint clinic mechanism through WeChat, the project has enhanced its capability to manage the entire process of ICI-related myocarditis and has ensured that elderly cancer patients can safely reap the survival benefits of immunotherapy."

Development and industrialization of miniaturization and low-cost AI digital CT system

Principal Investigator	Qisheng Xia, PhD
PI Primary Affiliation	China-Japan Friendship Hospital/Tsinghua University/Bright-Vison Medical Co.,Ltd.
Co-Investigator(s)	None

PROJECT DESCRIPTION

Stroke is the number one "killer" of human health, and is the leading cause of death and disability worldwide. Obtaining diagnosis and treatment during the golden time window is crucial for stroke patients. CT is the preferred imaging examination for stroke patients. However, the current spiral CT is bulky and expensive, making it difficult for primary hospitals to allocate resources and severely affecting the treatment effect of critical diseases such as stroke. There is an urgent need to develop a small, low-cost CT device.

The goal of the project is to develop a new generation of small, low-cost AI digital CT system.

The project achieves the goal of miniaturization and lightweight design of equipment through innovative imaging architecture design. It develops new CBCT reconstruction algorithms and AI image processing algorithms to improve the clarity of soft tissue imaging while reducing hardware costs, meeting the clinical diagnostic accuracy requirements of diseases such as cerebral hemorrhage.

This project is the first research and development project in the world based on AI image processing for digital CBCT, which will significantly improve the soft tissue imaging effect of CBCT. It is also the first digital imaging solution for stroke patients located in primary medical institutions, which will win valuable time for stroke patients in primary care. It is expected to have excellent application prospects in primary medical care, pre-hospital emergency care for stroke, neurological monitoring, and mobile medical diagnosis and treatment, replacing existing spiral CT in some specialized fields such as stroke detection.

Development of degradable magnesium gallium alloy barrier system for dental guided bone regeneration

Principal Investigator	Jian Zhou, D.D.S., Ph.D.
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PI Primary Affiliation	Beijing Stomatological Hospital, Capital Medical University
Co-Investigator(s)	Weiku Zhang, PhD; Jun He, PhD

PROJECT DESCRIPTION

With an aging population, the demand for dental implants is growing. However, a common challenge is insufficient bone volume at implant sites, which could be effectively addressed by guided bone regeneration. Traditional barrier mesh and screws are non-degradable, necessitating a secondary removal surgery, which increases patient discomfort and extra cost.

Based on this, we are developing biodegradable barrier mesh and screws. Our team discovered that the magnesium-gallium alloy, with its superior mechanical properties and consistent degradation, holds vast potential in the dental field.

Our aim is to engineer degradable magnesium-gallium alloy barrier mesh and screw while refining the strategies for guided bone regeneration.

Development of Neuroprotective System Based on Selective Hypothermia for Brain Injury

Principal Investigator	Ming Li, PhD
PI Primary Affiliation	Xuanwu Hospital and Beijing Institute for Brain Disorders, Capital Medical University
Co-Investigator(s)	Yue Jian,PHD ; Wang Xue,PhD ; Yang ZiXuan , PhD

PROJECT DESCRIPTION

Acute Ischemic stroke (AIS) has high mortality and disability rate. Reperfusion injury occurs after recanalization of blood vessels and there are no effective neuroprotective drugs, which lead to poor clinical outcomes after intravenous thrombolysis and mechanical thrombus removal. Mild hypothermia treatment is currently the most promising neuroprotective method, while whole body hypothermia is likely to cause side effects including chills, selective cold saline infusion hypothermia is likely to cause hemolysis and increase intracranial pressure, and it is difficult to accurately control temperature during a long time, and it is not possible to establish a standard hypothermia treatment plan for AIS patient, which has limited the application and promotion of this technology. Therefore, the research of brain disease and neuroscience requires a fast, accurate, safe and effective low-temperature brain protection device urgently. This project combines intravascular hypothermia technology with autologous blood transfusion hypothermia technology to develop a set of neuroprotection systems based on selective autologous blood hypothermia for brain injury, including the design of crucial parts such as stable flow rate and small flow magnetically driven centrifugal blood pump, miniaturized heat exchange oxygenation system, hypothermia-oriented intervention catheter, surface modification of the tubes used for circulation system and multi-parameter physiological monitor technology. The safety and effectiveness of the whole system will be verified by AIS animal model study. The hypothermia neuroprotective system will break through the technical bottleneck of the clinical application of hypothermia brain protection, offer a new tool for hypothermia neuroprotection research in brain disease and neuroscience.

Endovascular Thrombectomy for Acute Vertebrobasilar Artery Occlusion With Large Infarct Core

Principal Investigator	Chuanhui Li, MD
PI Primary Affiliation	Xuanwu Hospital of Capital Medical University

Co-Investigator(s)	Min Jin. MD. PhD ; Yuting Gu. MD. PhD ; Zhexiong Hu. MD ; Yifei Zhao. MD
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PROJECT DESCRIPTION

Stroke is a difficult to treat disease that seriously endangers human health and life safety in the world today. Acute ischemic stroke accounts for about 80% of all strokes, and the key to its treatment is to provide intravenous thrombolysis or endovascular thrombectomy as soon as possible after the attack and save the ischemic penumbra. Stroke caused by acute vertebrobasilar artery occlusion in the posterior circulation is the most severe type of ischemic stroke. If the occluded blood vessels cannot be reopened, the mortality rate and severe disability rate of patients are higher compared to those in the anterior circulation. However, for acute vertebrobasilar artery occlusion with large infarct core, it is currently uncertain whether endovascular therapy can achieve better prognosis compared to optimal medical treatment. This project aims to scientifically evaluate the safety and efficacy of endovascular treatment for acute vertebrobasilar artery occlusion patients with large infarct core through a prospective randomized controlled study.

Establishment of Cell Expansion System for Pluripotent Adult Lung Progenitors and Construction of Functional Lung Organoids

Principal Investigator	Bingfang Zhang, PhD
PI Primary Affiliation	Chinese Academy of Medical Sciences
Co-Investigator(s)	Xiaoyan Liu, MD, MS; Bing Mu, MD, PhD; Peng Wang, MD, PhD; Naiyuan Tian, MD, PhD; Yi Tian, MD, PhD; Bowen Zhou, MD, PhD; Zizheng Suo, MD; Wenjie Xu, MD; Yuxiang Zheng, MD

PROJECT DESCRIPTION

In chronic obstructive pulmonary disease or idiopathic pulmonary fibrosis, allogeneic lung transplantation, there are no effective treatments for acute lung epithelia damage. Cell therapy provide a novel insight into therapeutic approaches. However, the identified progenitors in lung cannot be expanded in large-scale in vitro and effectively drive lung regeneration in vivo. Now, we have developed a culture system for mouse multipotent adult lung progenitors, the cells can be expanded more than 35 generations and then be used to promote alveolar regeneration efficiently in pulmonary fibrosis. In this project, we will optimize the cell-culture system to make it more suitable for the expansion of human lung stem cells, which will improve clinical therapies to treat patients suffering from the burden of lung diseases, such as pulmonary fibrosis.

Organoids became outstanding models to study the pathogenic mechanism of organs, as well as clinical drugs screening. Currently, lung organoids are mainly derived from iPSCs, and the organoid size is small. Meanwhile, a respiratory organoid system with bipotential differentiation of the airway and alveolar epithelium remains elusive. Therefore, organoids cannot simulate the development process and homeostasis of the lung in vivo effectively. Now, we can construct tracheal organoids with branching morphogenesis and alveolar organoids with mature alveolar function. We will optimize the organoids culture system to build functional organoids that can highly mimic lung organs in vivo, which will be useful for studying the pathogenic mechanism of respiratory organs, as well as for clinical drug screening and drug toxicity evaluation.

Establishment of Low-dose Piecewise CT Technique and Development of AI 3D Reconstruction Measurement Software for Measuring Rotational Force Line of Lower Extremity in Patients with Osteoarthritis

Principal Investigator	Zhenpeng Guan, MD
PI Primary Affiliation	Peking University Shougang Hospital

Co-Investigator(s)

Ruirui Xing, PhD ; Guizhi Shen, PhD ; Sihang Cheng, MD;

PROJECT DESCRIPTION

Knee osteoarthritis (OA) has become a significant impact on the elderly health problems in the quality of life, its pathogenesis is complicated and interaction, the biomechanical factors that lower limbs osseous force line deformity is academia as one of the important risk factors. Coronal and sagittal force lines can be measured by full-length X-ray of lower limbs with low radiation dose (pure/lateral). However, in order to accurately measure the rotational force line of lower limbs, it must be measured by full-length CT scan of lower limbs with high radiation dose. This examination is often rejected by patients in clinical practice because of its excessive dose harm beyond the conventional radiation range of human body. There is no imaging sample bank for bone markers of lower limbs, and how to ensure the accuracy of CT imaging measurement data in patients with the lowest radiation dose is the focus of orthopedic and imaging doctors.

Based on this, the research team intends to establish a low-dose segmentary CT technique for measuring the rotational force line of lower extremity in patients with osteoarthritis. At the same time, AI-assisted CT scan 3D reconstruction bone marker measurement software was developed. We want to achieve the following goals :(1) to find the minimum radiation dose for patients that can measure accurate data of rotational bone markers of lower limbs; (2) With the aid of AI, a sample database of bone markers of lower limbs was established and fitted to obtain the gold standard of bone markers.

Hydrogel based on immunoactive peptides: Embolotherapy combined with chemoimmunotherapy for hepatocellular carcinoma

Principal Investigator

Zhiwei Wang, MD

PI Primary Affiliation

Peking Union Medical College Hospital

Co-Investigator(s)

None

PROJECT DESCRIPTION

Senile patients with liver cancer lack effective treatment methods for the reason that the majority of senile patients have high operation risk. This study aims to address the problem of difficult-to-remove and easily recurrent and metastatic local lesions encountered in the clinical treatment of elderly and middle-aged liver cancer, by focusing on the construction of a immune hydrogel system and minimally invasive drug delivery. This study used an orthotopic model of hepatocellular carcinoma to study the feasibility of the treatment mode of arterial embolization combined with chemoimmunotherapy in the treatment of mid- to late-stage liver cancer under digital subtraction angiography (DSA). The hydrogel system carrying clinical chemotherapeutic agents was accurately and targetedly delivered to the nutrient artery of liver cancer. On the one hand, through the targeted delivery of chemotherapy drugs, the in situ liver cancer cells are effectively "killed"; At the same time, the special rheological properties of immunoactive peptide hydrogel form embolism in tumor blood vessels, and "starve" tumor cells by cutting off blood supply, so as to achieve effective tumor shrinkage effect of in situ liver cancer. Immunoactive peptide hydrogels exert a long-lasting and synergistic immunomodulatory effect by continuously releasing active peptide components to prevent the recurrence and metastasis of liver cancer. This project expects to complete the dual role of vascular embolism superimposed on continuous immunotherapy for middle and advanced liver cancer on the newly constructed self-assembled immunoactive peptide hydrogel platform, realize the dual efficacy of ablation of primary tumor and prevention of recurrence and metastasis.

Interactive structure segmentation foundation model based on prompting technique for cervical cancer radiotherapy

Principal Investigator

Ruijie Yang, PhD

PI Primary Affiliation	Peking University Thrid Hospital
Co-Investigator(s)	Jianjun Ge, PhD, Chun Dai, PhD

PROJECT DESCRIPTION

At present, the total number of cancer annual incidence is about 20 million, 10 million for mortality globally. As the second modality for cancer treatment, radiotherapy is beneficial for 60- 70% cancer patients. Precise tumor targets and organs at risk (OARs) contouring, treatment planning and quality assurance are the most critical factors for the success of radiotherapy, also the most important and time-consuming tasks for radiation oncologists and medical physicists. Nowadays, these tasks are performed manually, with significant variance among different countries, regions, hospitals, radiation oncologists and medical physicists, which undermine severely the safety and quality, availability and consistency of radiotherapy.

The main objective of this project is to develop an interactive cervical cancer radiotherapy structure segmentation foundation model based on prompt technology. The model will achieve real-time interactive structure automatic segmentation for different institutions, different disease stages, multimodality images, and multiple clinical scenarios, without the need for model retraining. By using prompt technology combined with clinical information prior and updated clinical practice, the accuracy and robustness of radiotherapy structure segmentation algorithms will be improved, thereby solving the problem of complex structure and tumor target segmentation and breaking through the key bottleneck of clinical application. This will promote the precision, intelligence, and process automation of radiotherapy, improve quality and efficiency, safety and efficacy. The project aims to improve the homogeneity and accessibility of radiotherapy, contribute to standardizing and guiding clinical practice.

KAPOK system, a new ISF instrument using Fan's classification

Principal Investigator	Weidong Fan, MD.
PI Primary Affiliation	Cardiovascular Center, Seventh Affiliated Hospital of Sun Yat-sen University
Co-Investigator(s)	Yan Li, PhD; Yi Zhang, PhD; Xuemin Xue, PhD; Lin Li, PhD

PROJECT DESCRIPTION

Thoracic aortic disease is a serious disease that threatens human health and longevity. With the increase of age, the incidence rate increases year by year; therefore, more individualized requirements for endovascular coated stent implantation and in situ fenestration (ISF) of the left subclavian artery (LSA) have been put forward. The current problem of 6 difficult puncture of ISF and complications related to branch stent implantation have limited the success rate and popularity of this technique. In response to the above situation, by using our original aortic Fan's classification method, our research group has developed a new ISF device, namely KAPOK system. Altering the twisted vessel with a traction device to make puncture easier, and using a "hat" branch stent that clamps on the main stent, so that there is no residual stent in the aortic lumen. In vitro models and animal experiments are used for verification. The device is expected to reduce the difficulty of the procedure and the occurrence of complications, increase the popularity of the procedure, provide an effective channel for other later interventional therapies, and bring benefits to human health and longevity. Related patent and product model have been basically completed. The research group has been formed.

Leaflet Splitting Device for Prevention of Coronary Obstruction in Transcatheter Aortic Valve Replacement

Principal Investigator	Yuan Feng, MD.
PI Primary Affiliation	West China Hospital , Sichuan University
Co-Investigator(s)	Bin Zhang, MD; Chong Tang, MD;Keshi Zhang, MD ; Zhe Xue, MD

PROJECT DESCRIPTION

Aortic stenosis is a common cardiovascular disease with a high fatality rate, and minimally invasive transcatheter aortic valve

replacement (TAVR) has revolutionized its treatment paradigm with

the rapid rise in recent years. However, the risk of coronary

occlusion is one of the key problems in the whole life cycle

management of aortic stenosis in the era of TAVR, which restricts

the application of TAVR, ViV-TAVR and Redo-TAVR to more elderly

patients with aortic valve disease. Although coronary protection and

BASILICA technology have been proposed to prevent coronary

obstruction, they have many shortcomings. Through systematic

investigation, the project team intends to develop a special valve

leaflet cutting device based on the principle of BASILICA technology

to reduce the risk of coronary artery occlusion in these scenarios,

so that more elderly patients with aortic valve disease can benefit

from new minimally invasive interventional technologies and promote

the realization of "healthy and long life".The project is expected to design and manufacture a domestic leaflet cutting device that meets the standards and specifications of human applications, apply for at least two core patents, form a standardized operation process, complete FIM research, and lay the foundation for pre-market confirmatory testing.

Medical Engineering Transformation Of Multiple Wearable Products And Risk Warning Model Construction For Heart Failure And Sudden Cardiac Death

Principal Investigator	Tong Zou, PhD
PI Primary Affiliation	Beijing Hospital
Co-Investigator(s)	None

PROJECT DESCRIPTION

Aiming to address the significant demands of active health management for preventing heart failure and sudden cardiac death, which are characterized by high incidence, high risk, high mortality, and high disability rates, this project utilizes robust data integration techniques both within and outside hospitals to construct a comprehensive and efficient early warning model. By employing a "mathematical data dual drive" approach in technical research on multi-modal non-invasive wearable intelligent sensing devices, combined with long-term and multi-dimensional data analysis, the project aims to achieve successful product transformation implementation while optimizing the early warning model. The effectiveness of the early warning model as well as multiple non-invasive wearable mobile products will be validated through clinical research to establish a foundation for auxiliary diagnosis and treatment guidance. With support from an information cloud platform, a collaborative

medical center based on "Beijing Hospital" has been established to facilitate seamless coordination across various stages including China CDC - emergency center - tertiary hospital - community - home. Furthermore, an initial demonstration model of a system linkage big data analysis and management platform has been developed to enable proactive response towards aging-related cardiovascular diseases while promoting active health management.

Multimodal self-adaptive pathological complete response(pCR) determination after neoadjuvant therapy for breast cancer based on 5G communication

Principal Investigator	Yuan Peng , PhD
PI Primary Affiliation	Cancer Hospital, Chinese Academy of Medical Sciences
Co-Investigator(s)	Jintian Tang, MD, PhD; Robert Wang, PhD; Yao Zou, MS ; Qiang Xiong , BS

PROJECT DESCRIPTION

Breast cancer has become the world's largest cancer. While its curative effect is improving day by day, how to achieve non-invasive evaluation of the efficacy of neoadjuvant therapy (NAT) in breast cancer patients so as to avoid surgery has become a bottleneck problem in clinical diagnosis and treatment that needs to be broken through. Existing non-invasive assessment strategies are limited to single-center, single-modality modeling, and suffer from low performance and poor versatility. Therefore, in the early stage of this study, the data of breast cancer patients from multiple centers across the country were collected and the establishment of an artificial intelligence (AI) curative effect prediction model was preliminarily completed. On this basis, this project intends to build a high-quality, large-sample, multi-time series, and multi-modal standard data set powered by AI, and design a self-supervised multi-modal feature mining method and a multicenter-based federated meta-learning strategy. Finally, the establishment and verification of a high-performance and versatile judgment model for pathological complete remission (pCR) after NAT will be completed, and a 5G-enabled remote diagnosis solution will be promoted. This project proposes an intelligent analysis method for breast cancer curative effect from data to model and fully empowered by AI, which will help the theoretical research of multimodal medical data feature mining and model construction, and will help solve the problem of non-invasive judgment of NAT curative effect in breast cancer patients. Scientific issues, providing a new paradigm for the research of high-performance AI diagnosis and treatment assistance systems applicable to multi-centers.

New strategy for general anesthetics development

Principal Investigator	Xuemei Chen, associate professor
PI Primary Affiliation	Renji Hospital, School of Medicine, Shanghai Jiaotong University
Co-Investigator(s)	Songyang Liu, PhD; Shen Liu ,MD; Fu Gu, MD.

PROJECT DESCRIPTION

General anesthetics (GA) has been widely used in many aspects of clinical settings, however, the specific mechanism and clear targets of them is still a mystery, which makes it difficult to develop more safe and efficient GA with fewer side effects. For the first time, we constructed a genome-wide general anesthetic target screening system basing on live animals. Under general anesthetics, nematodes displayed a rigid and stimulus unresponsive state, when introducing random point mutations into its genome, some mutant nematodes developed resistance to GA, indicating that the mutated gene is involved in the general anesthesia process. Here we completed gene mutagenesis of more than 100,000 nematodes and obtained 32 all anesthetic drug-insensitive mutant strains, and found two general anesthetic-related genes. Based on the previous work, we will further identify the remaining 30 mutant strains with all anesthesia-related genes, and the candidate proteins obtained from the screening would be structurally resolved by cryo-EM to find the exact binding site for GA,

subsequently point mutation will be further constructed to verify the role of this molecular site in mammalian anesthesia, thus a new target for anesthetic drugs can be finally identified through the whole process. The screening of specific general anesthetic targets using this strategy will help us to walk out of the dilemma in the process of novel GA research and development, and hopefully drive the whole general anesthetic R&D related industry chain into a new high speed development channel.

Personalized dental implant materials for the alveolar bone of elderly patients based on mechanical adaptation

Principal Investigator	Eryi LU. MD. PhD
PI Primary Affiliation	Renji Hospital, Shanghai Jiao Tong University School of Medicine
Co-Investigator(s)	Lin Mei, PhD; Jinjie Zhang, PhD

PROJECT DESCRIPTION

Dental implant restoration for a missing tooth is now a routine treatment among elderly patients. However, decreased bone mass and quality in the elderly population leads to the enlarged difference in elastic modulus between the implant and the peri-implant bone, which induces the stress shielding effect and thereby aggravates bone resorption around the implant, resulting in a significant decrease in the success rate of dental implants among elderly patients. Therefore, it is crucial to develop personalized dental implants with high strength and low elastic modulus for elderly patients based on the strategy of mechanical adaptation.

To this end, our team have been devoted to "mechanical adaptation". We have successfully developed a novel titanium alloy dental implant with different elastic moduli utilizing equal channel angular pressing technology and verified that the novel titanium alloy dental implant with high strength and low elastic modulus had excellent biocompatibility. The proposed project aims ① to design and controllably produce novel titanium alloy materials with high strength and low elastic modulus; ② to systematically study the effect of the novel titanium alloy implants on bone regeneration and the mechanical information of implant and the peri-implant bone environment; ③ to establish a machine learning-based research and development system of the personalized titanium alloy implants with high strength and low elastic modulus. The strategy of mechanical adaptation to develop novel implants with high strength and low elastic modulus is promising for improving the success rate of dental implants in elderly patients.

Polygenic risk score for chronic obstructive pulmonary disease in Chinese population and its application in disease warning

Principal Investigator	Junling Pang, PhD
PI Primary Affiliation	Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences
Co-Investigator(s)	Yan Wang, MD, Hao Lu, MD, Huiyong Chen, MD

PROJECT DESCRIPTION

Chronic obstructive pulmonary disease (COPD) is the most serious chronic respiratory disease, which has a high incidence rate and mortality, resulting in a serious social medical burden. At present, the diagnosis and treatment of COPD in clinical practice mainly focus on patients in the middle and late stages, with poor prognosis. Therefore, it is crucial to achieve early screening and diagnosis of COPD. In this project, we will construct a polygenic risk score (PRS) model for early warning and prevention of COPD in Chinese population. Based on a genome-wide association study (GWAS) of a Chinese cohort, we will optimize the PRS model through traditional "C+T" method or machine learning-based methods. Furthermore, we will evaluate the effectiveness of the PRS model in an independent Chinese cohort. The results of this project are expected to have important practical application value for clinical risk assessment and early warning of COPD in Chinese population.

Research and Development of Chamaejasmenin B for the Treatment of Ischemic Stroke

Principal Investigator	Jiekun Xu, PhD
PI Primary Affiliation	Beijing University of Chinese Medicine
Co-Investigator(s)	ErPing Long, PhD; Jixin Wang, BS; Yitian Zhou, BS

PROJECT DESCRIPTION

Ischemic stroke seriously endangers the people health, however, there is still a significant lack of effective therapeutic drugs in clinical practice. Our team has discovered in recent years that Chamaejasmenin B isolated from the traditional Chinese medicine *Stellera chamaejasme* L. has significant treatment effect of ischemic stroke. There is a good neuroprotective effect on transient middle cerebral artery occlusion (tMCAO) injury in rats in vivo, which can improve histology after ischemia and promote neurobehavioral recovery. At the same time, it can regulate the balance of oxidative antioxidant system in brain tissue of rats with cerebral ischemia-reperfusion, and reduce the level of inflammatory factors. In addition, the results of toxicity studies in animals showed that Chamaejasmenin B has no obvious toxic or side effects. If Chamaejasmenin B is successfully developed, it will provide an innovative drug with high safety, definite treatment of ischemic stroke.

Research and effectiveness exploration of artificial intelligence diagnosis system and intelligent biopsy robot based on prostate cancer pathology and nuclear magnetic imaging

Principal Investigator	Huimin Hou, PhD
PI Primary Affiliation	Beijing Hospital
Co-Investigator(s)	Songlin Wang, D.D.S., Ph.D. Su Chen, D.M.D., Ph.D. Yan Li, Ph.D.

PROJECT DESCRIPTION

Prostate cancer is one of the most common malignant tumors in men. Early diagnosis is very important to improve the survival rate of patients. However, the existing diagnostic techniques that rely on MRI and prostate biopsy rely too much subjectively, resulting in inadequate diagnostic rate. This project aims to develop an artificial intelligence image recognition system and intelligent biopsy robot based on prostate cancer pathology and MRI, so as to improve the early diagnosis and treatment of prostate cancer.

Our system will utilize deep learning technology and computer vision algorithm to automate analysis and recognition of large pathological section images of prostate cancer. By constructing a deep convolutional neural network model and training and optimization of large-scale pathological image data of prostate cancer, accurate classification and segmentation of cancer cells, normal tissues and diseased areas were realized. The model will be able to accurately identify and label the location and extent of prostate cancer, providing diagnostic capability.

We will also develop an intelligent biopsy robot. By combining image recognition results and real-time ultrasonic guidance and matching image processing algorithm, the puncture target will be provided to the biopsy robot, and the biopsy will be completed by the robotic arm under the control of magnetic field.

The key technical challenges of the project include tagging a large number of pathological images of prostate cancer and repetition training, optimizing the accuracy and robustness of deep learning models, and achieving accurate matching of image recognition results to ultrasound images, and robotic arm guidance. We will rely on the hospital's clinical resources and professional team to work closely together to ensure the smooth progress of the project and the effective implementation of the results.

The expected project outcomes include a stable and reliable prostate imaging AI diagnostic system that can accurately identify the location and extent of prostate cancer in a relatively short period of time, and an intelligent puncture system to achieve integrated diagnostic results and improve diagnostic efficiency.

Selection strategy of cuff size of artificial urethral sphincter: based on real-time intraoperative urethral pressure profilometry

Principal Investigator	Lingfeng Meng, PhD
PI Primary Affiliation	Beijing Hospital
Co-Investigator(s)	Weigui Fu , PhD ; Jichun Yang , PhD

PROJECT DESCRIPTION

Urinary incontinence refers to any involuntary urine leakage, which seriously affects the daily life and psychological state of patients. Artificial urethral sphincter (AUS) implantation has become the gold standard for treatment of moderate to severe stress urinary incontinence. In principle, AUS implantation, like other anti-incontinence procedures, are designed to increase urethral resistance and thus achieve urinary control. At present, it is considered that the cuff with appropriate size is the key to achieve urinary control, but there is no standardized guide for cuff size selection in clinical practice, and the selection of cuff size during surgery mainly depends on the measured periurethral diameter of the patient. The cuff size increases / decreases in the unit of 0.5cm, and it is often encountered in the actual clinical work that the measured periurethral diameter of patients does not meet the integer multiple of 0.5cm. In this case, no consensus has been reached on the selection of slightly larger / smaller cuff. Therefore, the purpose of this study is to explore the scope of safe urinary pressure of the AUS device, and to guide the selection of the cuff during AUS implantation by measuring the pressure provided to the urethra by the AUS device. In the later stage, a standardized and feasible system based on intraoperative urethral pressure profilometry will be formed to guide treatment, efficacy evaluation and predict complications, and the application and promotion of a new evaluation method represented by intraoperative urethral pressure profilometry was completed.

The investigation for the role and mechanism of general immune activation-TEM cross barrier mechanism in the occurrence of perioperative neurocognitive disorders under synergistic effects of aging and multiple perioperative factors

Principal Investigator	Cheng Ni, MD, PhD
PI Primary Affiliation	National Cancer Center, National Clinical Research Center for Cancer, Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College
Co-Investigator(s)	Xunming Ji,, PhD & MD; Chuanjie Wu, MD; Longfei Wu, MD; Jian Chen, MD; Wenbo Zhao, MD

PROJECT DESCRIPTION

With population aging and indication expansion, tumor surgery in elderly patients is becoming increasingly widespread. Our studies suggest that perioperative factors such as aging, surgery, anesthesia, and tumor treatment can lead to systemic inflammatory reactions, and participate in the occurrence of perioperative neurocognitive disorders (PND) through T cell pathway. PND includes various perioperative central nervous system (CNS) dysfunctions such as POD and POCD, which affect postoperative recovery and long-term outcomes of patients. However, the mechanisms by which perioperative factors affect systemic immune function and related major organ dysfunction such as PND are unclear. Feasible perioperative immune response-PND intervention targets and strategy are urgent clinical issues. Intelligent research and translational exploration based on this foundation also have important clinical values. The main project research contents include:

1. Study the dynamic changes of systemic immune function, and the activation and intercellular interaction mechanism of TEM cells under the synergistic effects of multiple perioperative factors.
2. Study systemic immune activation-TEM cross barrier mechanism, and establish the p53-PGC-1 α -NRF-1 mitochondrial pathway and associated gene regulatory network for TEM activation. Then study the pathological process of mechanism of PND associated BBB injury-CNS inflammation.
3. Apply dexmedetomidine combined anesthesia and analgesia strategy to intervene the mitochondrial pathway and cross barrier effects of TEM cells on PND pathogenesis.
4. Establish an intelligent analysis model for systemic immune function, and a prediction model for PND and postoperative recovery. Provide an intelligent support system for the diagnosis and treatment of perioperative immune response related organ dysfunction.

The research and development of anti-obesity innovative drug MD02 targeting UCP1

Principal Investigator	Guifen Qiang, PhD
PI Primary Affiliation	Institute of Materia Medica, Chinese Academy of Medical Sciences & Peking Union Medical College
Co-Investigator(s)	Ge Junbo, PhD; Shen Li, PhD;

PROJECT DESCRIPTION

The increasing prevalence of obesity in children is a growing concern due to the potential health problems they may face in middle age and beyond. Obesity is a significant risk factor for metabolic diseases, including diabetes, cardiovascular and cerebrovascular diseases, and tumors. The development of safe and effective weight-loss drugs has been a challenge, with many drugs being subject to FDA black box warnings or withdrawal. This project aims to explore a new therapy by targeting the thermogenic gene uncoupling protein 1 (UCP1) in adipose tissue to reduce adipose and combat obesity. The researchers used CRISPR/Cas9 gene editing technology to establish a screening model for UCP1 inducers and identified a lead compound called MD02. Preclinical evaluations in obese mice and rats demonstrated that MD02 had significant anti-obesity activity, reducing adiposity, improving glucose metabolism, through promoting white adipose tissue browning and brown adipose tissue thermogenesis. The next steps involve investigating the mechanism of action of MD02 and conducting comprehensive pharmaceutical studies, including formulation, stability, and safety evaluations. The researchers have completed preliminary evaluations and applied for patents. They aim to submit an application for clinical trials and publish scientific articles to support the development of MD02 as a novel anti-obesity drug. The goal is to provide an innovative drug that can improve the health of obese patients, reduce the incidence and death of metabolic diseases.

Throat flora as a predictive marker of hereditary angioedema and its mechanism

Principal Investigator	Xue Wang, MD
PI Primary Affiliation	Peking Union Medical College Hospital, Peking Union Medical College & Chinese Academy of Medical Sciences
Co-Investigator(s)	None

PROJECT DESCRIPTION

Hereditary angioedema (HAE) is a rare, life-threatening autosomal dominant disorder characterized by recurrent, unpredictable episodes of skin and mucosal swelling. Asphyxia due to laryngeal edema is a common cause of death in patients. Previous studies by our team found that dysbiosis of the throat flora is associated with

episodes of laryngeal edema, but the causal relationship is unclear, and the mechanism is unknown. Based on the established HAE prospective cohort, this study will elucidate the causal relationship between throat flora dysbiosis and laryngeal edema episodes. In addition, this study will explore the mechanism of laryngeal flora changes causing edema based on an animal model of HAE. The study will build an early warning model of acute laryngeal edema based on throat flora to assist physicians in identifying active patients and adjusting clinical interventions in a timely manner, which will provide new solutions to improve the quality of life and ensure the safety of HAE patients.

Utilization of neurovascular coupling surveillance predicated on the modulation of brain-network functionalities in the diagnosis and therapeutic intervention of PND in geriatric patients

Principal Investigator	Li Tian, M.D., PhD; professor of Tongji University, deputy director and professor of Shanghai Key Laboratory of Anesthesiology and Brain Function Regulation; PI of Shanghai Research Institute for Intelligent Autonomous Systems.
PI Primary Affiliation	Shanghai Fourth People's Hospital Affiliated to Tongji University
Co-Investigator(s)	Yaoguang Zhang, MD; Minggxiao Wu, MD; Zhipeng Zhang, MD; Jinfu Wang, MD; Wei Zhang, MD; Xiaodong Liu, MD.

PROJECT DESCRIPTION

Elderly individuals are particularly vulnerable to the onset of perioperative neurocognitive disorders (PND), predominantly attributed to deteriorations in brain functionality. Despite this, clinical practice lacks standardized methodologies for prevention and intervention. However, a comprehensive, multi-dimensional approach to monitoring brain network functionality can be employed, encompassing robust preventative measures in the preoperative phase, vigilant monitoring and management during the intraoperative period, and swift postoperative interventions with early warning systems.

The symbiotic relationship between neuronal activity and vascular responses is pivotal in preserving brain homeostasis. Neurovascular coupling, a process involving localized cerebral blood flow alterations in response to neuronal activity, is often implicated in various brain injury-related disorders, PND included, due to its impairment. The coupling of functional near-infrared spectroscopy (fNIRS), electroencephalography (EEG), and functional magnetic resonance imaging (fMRI) enables the precise, comprehensive, and real-time monitoring of brain activity, effectively addressing the limitations of standalone methods.

In conjunction with the Perioperative Cognitive Assessment System (PNAS) that we have developed and digital therapies such as gaming, music, and art, we have established a precise and accurate framework for the assessment and intervention of perioperative neurocognitive disorders.