武汉大学人民医院
实验动物福利伦理审查结果告知书
Renmin Hospital of Wuhan University
Notification of the Result for Ethical Approval for Research Involving Animals

实验项目名称 Program	颅温颅压光纤动态监测系统研究 Research on fiber-optic dynamic monitoring system of cranial temperature and pressure		
编号 IACUC Issue No.	WDRM动（福）第 20240501A 号		
项目负责人 Name of Principal Investigator	王峻 WangJun	电话 Contact Tel.No.	17762495223
		电子信箱 Contact Email	drwangjun@whu.edu.cn

实验动物福利伦理审查结果告知书内容

Content of the notification

该项目福利伦理审查结果如下：

The result of the application for ethical approval：

■通过审查，有效期：2024年5月7日 至 2025年1月21日

■Approve, period of validity: 7 May 2024 TO 21 Jan 2025

武汉大学人民医院 实验动物伦理委员会 Laboratory Animal Welfare & Ethics Committee Renmin Hospital of Wuhan University

实验动物伦理委员会

Laboratory Animal Ethics Committee

2024年(Y) 5月(M) 6日(D)

备注：通过审查的项目，在有效期届满10个工作日前，由科室负责人/项目负责人（或指定人员）向IACUC提出延期年度审查备案申请。

通过审查的项目，动物实验项目结束时，项目负责人应向IACUC提出福利伦理监督检查的申请。

未通过审查的项目，请按IACUC的建议修改实验方案或补充新资料，申请复审。

Remarks: When the program application approved, the applicant should submit a deferred annual approval application to IACUC, 10 days before expiry date.

When animal experiment program completed, the applicant whose program application have been approved should submit an application of welfare & ethics supervision and inspection to IACUC.

When the program application disapproved, the applicant should submit the Application Form again according to the opinion IACUC giving.

主任委员（或授权的副主任委员）签字：
Signature of Director:

People's Hospital of Wuhan University

Application for ethical review of experimental animal welfare

NUMBER：WDRM 20240501A

Ⅰ、Item information

<table>
<tr><td colspan="4">Project name (Chinese) and project number：颅温颅压光纤动态监测系统研究
Project name (English)：Research on fiber-optic dynamic monitoring system of cranial temperature and pressure</td></tr>
<tr><td colspan="4">Project type： ☑scientific research ☐Teaching experiment</td></tr>
<tr><td colspan="4">Project source：☐Major national projects ☐National Natural Science Foundation ☑Key R&D projects in Hubei Province</td></tr>
<tr><td rowspan="3">Project leader</td><td rowspan="3">Wang jun</td><td>Title/position: tutor/person in charge</td><td>Email: drwangjun@whu.edu.cn</td></tr>
<tr><td colspan="2">Office (laboratory) room telephone：81070</td></tr>
<tr><td colspan="2">Laboratory address: First Clinical College of Wuhan University</td></tr>
<tr><td rowspan="2">Contacts</td><td rowspan="2">Lv Hao</td><td>Title/position: student</td><td>Email: 915481302@qq 还 om</td></tr>
<tr><td colspan="2">telephone：18871100056</td></tr>
<tr><td colspan="2">The validity period of the proposed application</td><td colspan="2">2024/01/21 — 2025/01/21</td></tr>
</table>

Ⅱ、Qualification of animal experiment operators

<table>
<tr><td colspan="4">Animal experimental facilities: Animal Center Building, People's Hospital of Wuhan University
License number of animal experimental facilities：SYXK（鄂）2020-0027</td></tr>
<tr><td>Name</td><td>Project responsibilities</td><td>Professional title</td><td>Laboratory animal practitioners assessment certificate number</td></tr>
<tr><td>Zhang Xu</td><td>Operation assistant</td><td></td><td>TY20180169</td></tr>
</table>

Ⅲ、Basic information of experimental animals

variety	Age	Weight	Gender	Mode of transport	Feeding environment
rabbit	One year	4-5kg	male	truck	General environment

IV、Reasons for animal use and retrieval of alternative methods

a、Explain why the animal species to be used in your research are reasonable.

☑This experiment is a direct continuation of previous animal experiments using this species.

☐ This study is devoted to expanding the previous experimental results from other varieties to this variety.

☐ At present, there is a lack of understanding of the important physiological/behavioral phenomena of this species of animals.

☐We know more about the important physiological/behavioral phenomena of this species of animals than other species.

☑The selection of this variety reflects the best compromise between the lowest organism that can be used and the model system that is closest to human physiology/behavior.

☑ This variety is the most economical for the planned research.

☐ Others (please explain):

b、What is the reason for using live animals in this experiment?

☑This study requires behavioral measurement of living animals.

☐ This study is devoted to expanding the previous experimental results from other varieties to this variety.

☑This study requires biological testing of living animals or taking tissue samples from living animals.

☑ In this experiment, computers or other models cannot replace animals.

☑ We can't do in vitro experiments in this study.

☑ Others (please explain):

c、The basis of the number of animals needed

☑ Statistical analysis shows that the number of animals in the experimental plan is the least, which meets the requirements of effective testing of experimental hypotheses statistically.

☐The experiment will compare the results of multiple independent factors, so multiple groups are required.

☐The detection of results or detected phenomena is variable, and a large sample size is necessary for statistically effective sampling.

☐The difference from the control group is expected to be small. For the difference between reliable regional groups, a large sample size is necessary

☑The experiment is technically difficult, and it needs many attempts to obtain satisfactory data from each experiment.

☐ Others (please explain):

d、Find alternative methods for living animals.

1、List at least 2 kinds of databases to consult. (Such as: China HowNet, PubMed, etc.)

China HowNet、PubMed

2、Retrieval date: 2024-01-17 3、Retrieve the year covered: 2018-2023

4、Key words related to animal welfare: animal model, in vitro, substitution, rabbit model of high intracranial pressure, intracranial temperature and intracranial pressure, optical fiber sensing, interventional measurement.

5、Key words related to the project: animal model, in vitro, substitution, rabbit model of high intracranial pressure, intracranial temperature and intracranial pressure, optical fiber sensing, interventional measurement.

Explain that animals must be used instead of non-animal alternatives:

Animals are needed to simulate craniotomy, endoscopic sinus surgery and laparoscopic surgery, and animal models are needed to provide experimental data in vivo.

Ⅴ、Research purpose and significance

Taking the general non-biomedical background personnel as the object, describe the research purpose in popular language (what to do?), the contribution to human, animal health or science (why?) (Avoid using abbreviations and abbreviations)

Flexible surgical tools: We have made a special surgical tool, which is firm and flexible, and can adapt to the operation in a narrow nasal cavity. This tool can bend and twist, and at the same time, it can sense changes in strength and shape, which helps to perform surgery more accurately. Using artificial intelligence to identify nasal cavity structure: We developed a method based on artificial intelligence to identify different tissues in the nasal cavity and clearly display these tissues in a three-dimensional model. In this way, we can better understand the specific situation of the operation area before the operation. High-precision 3D model construction: Through special light projection technology, we can

construct a high-precision 3D model of the operation area, which is very helpful for the preparation and planning of the operation. Tracking the position of surgical tools in real time: Combining image data and optical fiber sensing technology, we can track the position and posture of surgical tools in the nasal cavity in real time to ensure the safety and accuracy of the operation. Intelligent path planning: We studied how to plan the moving path of surgical tools in a complex nasal environment to avoid important tissues and reduce risks. Man-machine natural interaction and flexible operation: Through the advanced control model, the surgical robot can naturally interact with the doctor and perform the operation flexibly. Animal and corpse experiments: During the development process, we will conduct experiments on animals and human corpses to test and improve the system. Aiming at the developed optical fiber cranial temperature and intracranial pressure monitor, the monitoring experiment of cranial temperature and intracranial pressure in living animals (rabbits) was carried out to verify the accuracy and safety of the device measurement.

Ⅵ、Experimental plan (design) and basic experimental operation

<table>
<tr><td rowspan="5">Genetic engineering animal reproduction</td><td colspan="2">☐Yes, fill in the following table. ☑No</td></tr>
<tr><td>Breeding mode</td><td></td></tr>
<tr><td>Identification time of suckling rats</td><td></td></tr>
<tr><td>Time of weaning</td><td></td></tr>
<tr><td>Treatment of negative mice</td><td></td></tr>
<tr><td></td><td colspan="2">1、Experimental grouping (describe experimental group, control group and number of animals)
Cranial surgery model construction and manipulator-assisted intracranial operation experiment: 3 experimental rabbits
robot-assisted abdominal surgery model construction and operation experiment: 3 experimental rabbits.
Application experiment of robot-assisted six-axis force sensing clamp in surgery: 3 experimental rabbits</td></tr>
</table>

Blood pressure and intracranial temperature monitoring experiment: 3 experimental rabbits and 2 spare experimental rabbits.

2、Main experimental process

Time	Content
7 days before the experiment	Adaptive feeding
Experimental day	Three experimental rabbits were taken. (1) After induced anesthesia, the doctor removed the hair on the right side of the rabbit's head and drew an incision line on the rabbit's scalp. The size of the bone window was about 12× 8 mm. (Operator: doctor; Using instruments: skin marker) (2) The doctor used a scalpel to cut the scalp, exposed the skull, and used bipolar electrocoagulation to stop bleeding. (Operator: doctor; Instruments used: scalpel, bipolar electrocoagulation) (3) Students control the mechanical arm, so that the surgical drill equipped with a force sensor can drill a φ 3 mm hole in the skull of the rabbit scalp incision position. Based on Labview and Matlab software, the sudden reduction of the axial force of the sensor is judged as the condition that the drill bit is about to break through the skull. At this time, the mechanical arm is controlled to stop feeding, and the drilling is completed by retreating, during which the normal saline is used for flushing and cooling. (Operator: students and doctors; Instruments used: mechanical arm, force sensor, surgical electric drill, φ 3 mm drill, irrigator; Feed parameters: 6000rpm, 0.1mm/s) (4) The students change the 2mm grinding head of the towel, control the mechanical arm, and use the surgical drill equipped with a powerful sensor to grind and enlarge the hole until the size of the bone window reaches 12x8mm, during which the flusher is used to wash and cool down. (Operator: students and doctors; Instruments used: force sensor, surgical electric drill, φ Φ2mm grinding head and washer; Feed parameter: 6000rpm)

	Experimental day	In addition, three experimental rabbits were selected. (1) Move the cart to make the robot system reach the target position. (2) Adjust the height and angle of the operating table. (3) disinfection and sterilization sheet. (4) Adjust the height and angle of the bracket to ensure that the end of the surgical robot is aligned with the center of the rabbit abdomen, and then move the cart backwards. (5) Fix the operating table and the rabbit. The doctor took a median incision in the abdomen. (6) Move the cart forward to make the surgical robot enter the abdominal cavity. (7) The doctor guides the operation process in real time, and the main operator completes grasping the rabbit stomach, colon and small intestine with both arms under the visual guidance. (8) Exit the flexible robot and disinfect after the experiment is completed.
	Experimental day	In addition, three experimental rabbits were used to perform some surgical tasks with six-axis force sensing pliers. Task 1 was to touch the tissue; Task 2-Clamping tissue; Task 3-Twist the organization; Task 4: Sewing and knotting.

Time	Content
Experimental day	In addition, three experimental rabbits were selected. (1) Blood pressure test: (1) Cutting off the hair in the groin of experimental rabbits; (2) hemostatic forceps was used to separate the femoral nerve, and then the connective tissue between the femoral artery and vein was separated, and the femoral vein was clearly exposed, and a section of vein was separated, about 5cm. Carefully separate the femoral artery, and separate the femoral artery from its tissues, about 5 cm long; (3) clamp the proximal end of the muscle artery with an artery clamp, and tie the proximal end with a thin thread. Pull this thread to cut the blood vessel near the distal end and insert an arterial trocar or plastic into the heart. (4) Insert the optical fiber single FP sensor into the arterial trocar or plastic tube, record the sensor data, slowly push the sensor about 8-10cm, and then slowly pull it out, the process lasts about 1 min； ; (5) Replace the dual FP sensor and the optical fiber FP+FBG sensor respectively, repeat the above process (4) and record the data respectively to shoot the experimental video. (2) Cranial temperature and intracranial pressure test: (1) Dip a cotton swab into 2% iodine and 75% medical alcohol to disinfect the skin of the experimental rabbit head; Using a scalpel to remove the hair from the head of the experimental rabbit, and making a straight incision with the middle seam at the top of the experimental rabbit's brain, the scalp, subcutaneous tissue and periosteum of the experimental rabbit were cut, and then the skull was exposed. (2) Drill a 3-5mm round hole about 1 cm outside the sagittal suture line and about 1 cm behind the coronal suture line of the experimental rabbit skull, insert an epidural needle at the first drilling hole, put the optical fiber single FP sensor and the medical ICP monitoring probe into the epidural pinhole at the same time and extend into the epidural area for about 1-2cm, and record the data of cranial temperature and intracranial pressure. The whole process lasts for about 2min. (3) extend 5F catheter into the epidural area from the hole drilled in the opposite side, and slowly inject about 5ml of normal saline into it, then slowly pull out the single FP sensor, record the experimental data and take experimental photos; (4) Insert the optical fiber double-F-P sensor into the epidural needle slowly to the epidural area, record the data of cranial temperature and intracranial pressure, then inject about 5ml of normal saline through the catheter, and slowly pull out the sensor, and the whole process lasts for about 2-3min; (5) slowly insert the fiber FBG+FP sensor into the epidural needle to the epidural area, record the data of cranial temperature and intracranial pressure, then inject about 5ml of normal saline through the catheter, slowly pull out the sensor, and the whole process lasts for about 2-3min, record the experimental data and take experimental photos and videos; (6) Pull out the medical ICP monitoring catheter and the 5F catheter.

Describe the experimental plan (design) and main facts of the project Test operation procedure	3. Animal experimental administration (such as intragastric administration, injection, dermal administration, implantation, etc.) ☐Yes, fill in the following table. ☑No 4、Draw blood ☐Yes, fill in the following table. ☑No Frequency (on what day of the experiment?): Blood collection site: Maximum blood collection per animal at a time: 5、The harm that the experiment is expected to cause to animals：☐Tumor growth ☐Gain or lose weight ☐Lose the ability to eat and drink ☑ die Other circumstances that need to be explained. Injury: transportation stress, long-distance transportation may lead to stress reactions in animals, such as anxiety and fear; Feeding environment, single cage feeding may lead to social isolation and behavioral disorder. Prevention and control measures: use appropriate transport cages and maintain appropriate temperature and humidity control; Provide enough water and food during transportation; Ensure that the cage is clean and has enough space to avoid overcrowding; Provide a suitable environment, such as toys or chews. Injury: Surgical operation may lead to bleeding, infection and pain. Prevention and control measures: aseptic operation, bipolar electrocoagulation to stop bleeding, and antibiotics to prevent infection after operation.

	Injury: Insertion of cannula and sensor may cause tissue damage. Prevention and control measures: careful operation, avoiding excessive force, and providing appropriate pain relief and nursing after operation. Injury: intraoperative hypothermia. Prevention and control measures: use a heating pad to keep your body temperature. 6、Main experimental process (modeling or surgical process) 1、Construction of skull surgery model and experiment of intracranial operation assisted by mechanical arm：Three experimental rabbits were taken. (1) After induced anesthesia, the doctor removed the hair on the right side of the rabbit's head and drew an incision line on the rabbit's scalp. The size of the bone window was about 12× 8 mm. (Operator: doctor; Using instruments: skin marker) (2) The doctor used a scalpel to cut the scalp, exposed the skull, and used bipolar electrocoagulation to stop bleeding. (Operator: doctor; Instruments used: scalpel, bipolar electrocoagulation) (3) Students control the mechanical arm, so that the surgical drill equipped with a force sensor can drill a φ 3 mm hole in the skull of the rabbit scalp incision position. Based on Labview and Matlab software, the sudden reduction of the axial force of the sensor is judged as the condition that the drill bit is about to break through the skull. At this time, the mechanical arm is controlled to stop feeding, and the drilling is completed by retreating, during which the normal saline is used for flushing and cooling. (Operator: students and doctors; Instruments used: mechanical arm, force sensor, surgical electric drill, φ 3 mm drill, irrigator; Feed parameters: 6000rpm, 0.1mm/s) (4) The students change the 2mm grinding head of the towel, control the mechanical arm, and use the surgical drill equipped with a powerful sensor to grind and enlarge the hole until the size of the bone window reaches 12x8mm, during which the flusher is used to wash and cool down. (Operator: students and doctors; Instruments used: force sensor,

	surgical electric drill, φ Φ2mm grinding head and washer; Feed parameter: 6000rpm) 2、Model construction and operation experiment of robot-assisted abdominal surgery：three experimental rabbits were selected. (1) Move the cart to make the robot system reach the target position. (2) Adjust the height and angle of the operating table. (3) disinfection and sterilization sheet. (4) Adjust the height and angle of the bracket to ensure that the end of the surgical robot is aligned with the center of the rabbit abdomen, and then move the cart backwards. (5) Fix the operating table and the rabbit. The doctor took a median incision in the abdomen. (6) Move the cart forward to make the surgical robot enter the abdominal cavity. (7) The doctor guides the operation process in real time, and the main operator completes grasping the rabbit stomach, colon and small intestine with both arms under the visual guidance. (8) Exit the flexible robot and disinfect after the experiment is completed. 3、Application experiment of robot-assisted six-axis force sensing clamp in surgery：In addition, three experimental rabbits were used to perform some surgical tasks with six-axis force sensing pliers. Task 1 was to touch the tissue; Task 2-Clamping tissue; Task 3-Twist the organization; Task 4: Sewing and knotting. 4、Monitoring experiment of blood pressure and cranial temperature and intracranial pressure：In addition, three experimental rabbits were selected. (1) Blood pressure test: (1) Cutting off the hair in the groin of experimental rabbits; (2) hemostatic forceps was used to separate the femoral nerve, and then the connective tissue between the femoral artery and vein was separated, and the femoral vein was clearly exposed, and a section of vein was separated, about 5cm. Carefully separate the femoral artery, and separate the femoral artery from its tissues, about 5 cm long; (3) clamp the proximal end of the muscle artery with an artery clamp, and tie the proximal end with a thin thread. Pull this thread to cut the blood vessel near

	the distal end and insert an arterial trocar or plastic into the heart. (4) Insert the optical fiber single FP sensor into the arterial trocar or plastic tube, record the sensor data, slowly push the sensor about 8-10cm, and then slowly pull it out, the process lasts about 1 min； ; (5) Replace the dual FP sensor and the optical fiber FP+FBG sensor respectively, repeat the above process (4) and record the data respectively to shoot the experimental video. (2) Cranial temperature and intracranial pressure test: (1) Dip a cotton swab into 2% iodine and 75% medical alcohol to disinfect the skin of the experimental rabbit head; Using a scalpel to remove the hair from the head of the experimental rabbit, and making a straight incision with the middle seam at the top of the experimental rabbit's brain, the scalp, subcutaneous tissue and periosteum of the experimental rabbit were cut, and then the skull was exposed. (2) Drill a 3-5mm round hole about 1 cm outside the sagittal suture line and about 1 cm behind the coronal suture line of the experimental rabbit skull, insert an epidural needle at the first drilling hole, put the optical fiber single FP sensor and the medical ICP monitoring probe into the epidural pinhole at the same time and extend into the epidural area for about 1-2cm, and record the data of cranial temperature and intracranial pressure. The whole process lasts for about 2min. (3) extend 5F catheter into the epidural area from the hole drilled in the opposite side, and slowly inject about 5ml of normal saline into it, then slowly pull out the single FP sensor, record the experimental data and take experimental photos; (4) Insert the optical fiber double-F-P sensor into the epidural needle slowly to the epidural area, record the data of cranial temperature and

<table>
<tr><td></td><td>intracranial pressure, then inject about 5ml of normal saline through the catheter, and slowly pull out the sensor, and the whole process lasts for about 2-3min; (5) slowly insert the fiber FBG+FP sensor into the epidural needle to the epidural area, record the data of cranial temperature and intracranial pressure, then inject about 5ml of normal saline through the catheter, slowly pull out the sensor, and the whole process lasts for about 2-3min, record the experimental data and take experimental photos and videos; (6) Pull out the medical ICP monitoring catheter and the 5F catheter.
7、Sample collection：☐Yes, fill in the following table. ☑No
<table>
<tr><td>sample name</td><td>Position</td><td>Frequency or time point</td><td>Way</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Whether toxic chemicals or drugs are used.</td><td>☑Not used ☐Used，Please describe the source：</td></tr>
<tr><td>Using recombinant DNA or pathogenic microorganisms</td><td>☑Not used ☐Used，Please describe the source：</td></tr>
<tr><td>Potential harm to personnel health</td><td>Basically no</td></tr>
<tr><td>Possible access routes for direct contact personnel</td><td>☐ Inhalation ☐ digestive tract, ☑ skin contact
☐ injection
Others (specify)：</td></tr>
</table>

Protective measures	☐Gas mask ☐safety glasses (or sealed protective glasses)☑gloves ☑protective clothing ☐mechanical ventilation cage ☐fume hood ☐ biological safety cabine ☐other (special)

Ⅶ、Anesthesia of experimental animals

According to experiments, the pain, stress or discomfort caused by animals are classified.

If it belongs to category 3, it is necessary to use scientific judgment methods to explain why the persistent pain and discomfort caused by experimental treatment cannot be alleviated by anesthesia, analgesia or sedation. Briefly describe the persistent pain and discomfort that may occur, the solution or that there is no feasible solution.

1	It only causes temporary pain and does not eed anesthesia; Or painless and stress-free.	☐ Yes ☐ No
2	Pain and/or stress can be relieved by appropriate methods.	☑ Yes ☐ No
3	Appropriate methods cannot be used to relieve pain or persistent discomfort.	☐ Yes ☐ No

Description (narcotic drugs and anesthesia methods)

Pentobarbital sodium was injected intraperitoneally to prepare 3% aqueous solution, 1 ml/kg; Local injection of lidocaine, a local anesthetic, at the operation site to relieve the pain at the operation site; Inhalation of isoflurane can maintain stupor, and the initial concentration is 1-3%. During the operation, the vital signs such as breathing, heart rate and pupil reaction of rabbits are continuously monitored, and the concentration of isoflurane is adjusted as needed to maintain a proper anesthesia depth.

Ⅷ、Treatment methods of experimental animals after experiments

1、Animal handling methods after the experiment and other problems to be explained.

☑ Overdose anesthetic

☐ Carbon dioxide inhalation

☐ Physical methods (cervical dislocation, decapitation, etc.)

☐ adopt

Other issues to be explained.

Pentobarbital sodium, intravenous administration.，100mg/kg

2、The end point of kindness or the end of experiment (that is, the time to end the experiment)。

Animal welfare: the welfare of rabbits should be closely monitored in the experiment. If you find any obvious pain, distress, loss of vitality, abnormal behavior or other signs of discomfort, you should immediately terminate the experiment and provide necessary care and treatment. Trauma and pain: especially in head surgery and intracranial pressure test, make sure that rabbits don't experience too much trauma and pain. If there are any obvious abnormalities, such as excessive bleeding, infection, increased intracranial pressure, etc., the experiment should be terminated and appropriate medical care should be provided. Scheduled end point: Before the experiment begins, researchers should set clear end point standards, including monitoring animal's physiological parameters, pain degree, blood pressure, cranial temperature and intracranial pressure. When these standards reach or exceed the predetermined value, the experiment should be terminated. Experimental purpose and scientific value: the scientific purpose and value of the experiment should also be considered. If enough data has been obtained or the experimental goal has been achieved, the experiment can be terminated in advance to reduce the discomfort to animals. Observe and monitor at any time: During the experiment, observe and monitor the state of animals at any time, including postoperative recovery, diet and behavior. If you find any problems, you should take immediate action.

IX、Statement of the project leader

. I guarantee that the statements made here are complete and accurate, and the animal use in this scheme does not simply repeat the previous experiments.

. If the scheme is approved, I agree to inform the experimental animal welfare ethics committee of any emergency in writing, and I agree that I will not continue the experiment until the problem is solved.

. I will not make any major changes to the procedures involving animals until the written revised draft of the experimental scheme is submitted to the welfare ethics committee of experimental animals and reviewed and approved by the ethics committee.

. It is my duty to ensure that every animal-related worker receives appropriate training.

. I will not start the experimental operation described in this scheme until I receive the approval notice from the welfare ethics Committee of experimental animals.

. I will keep a copy of this experimental scheme and all subsequent correspondence materials.

Project leader (signature):