Development and Validation of an Artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP

Short Title：Endoangel Study

NCT	-
Trial number	EA-19-003
Protocol version	1.2
Version date	Apr13, 2021
Country	China
Device	EndoAngel™
Principal investigator	Professor HonggangYu
Address	No. 99, Zhangzhidong Road, Wuchang District, Wuhan, Hubei.

Content

1. Summary

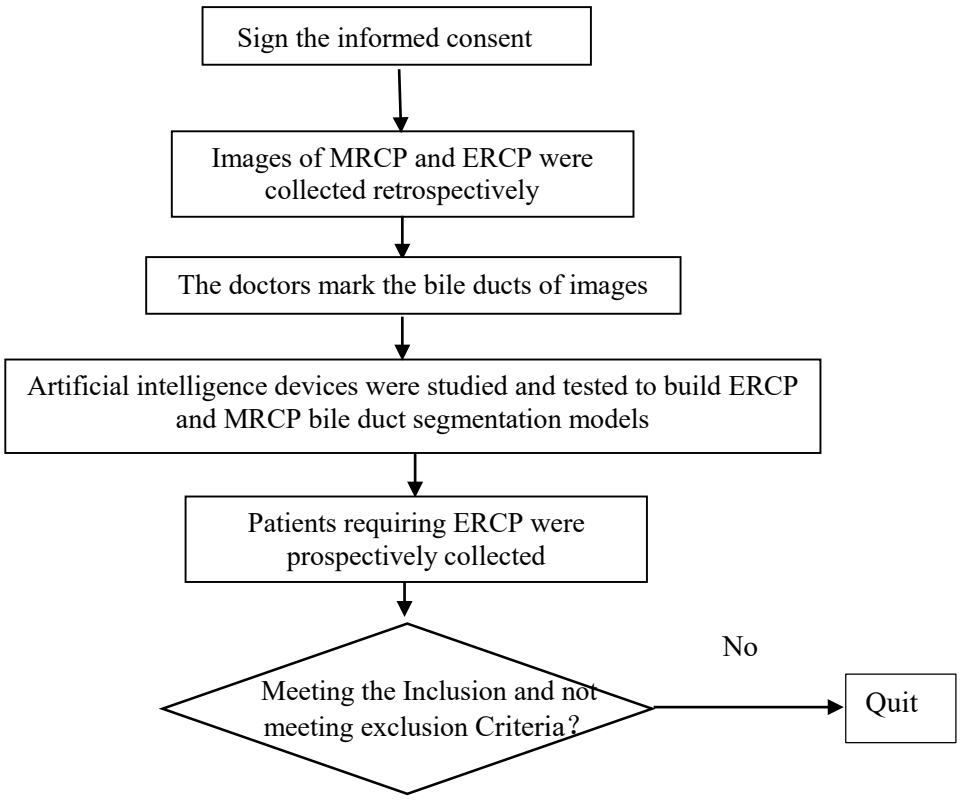
Title:	Development and Validation of an Artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP
Short Title:	*EndoAngel Study*
Trial number:	EA-19-003
Research system	EndoAngel
Expected effect:	ENDOANGEL's intended use is to instruct the direction of guide wire and the position of stent placement in real time.
Primary Endpoint:	Procedure time
Secondary Endpoints:	1.Intersection over union of bile duct segmentation 2. Intersection over union of bile duct matching model 3.Success rate of stent placement 4.Rate of adverse events 5. Fluoroscopy time 6.Total amount of contrast medium
Trail design:	Prospective, single-center, randomized controlled trial
Participants:	Male and female subjects aged 18 years or older will require MRCP and ERCP, and voluntarily provide imaging data of MRCP and ERCP, and sign an informed consent form.
Sample size:	62 samples needed to be enrolled
Study Process:	Subjects who met all inclusion criteria and did not meet all exclusion criteria were included in the study before ERCP. All included subjects signed an informed consent form. Subjects will be randomized prior to the start of the examination to either an Endoangel-assisted experimental group or a control group without Endoangel assistance. The operating physician completed ERCP according to the presence or absence of AI prompt. The recorder shall record procedure time, intersection over union of bile duct segmentation, intersection over union of bile duct matching model, success rate of stent placement, rate of adverse events, fluoroscopy time and total amount of contrast medium etc. Follow-up will be performed for one week after the end of examination. The end time of follow-up is the end time of study. And the results are sent to an independent data analysis team for review.

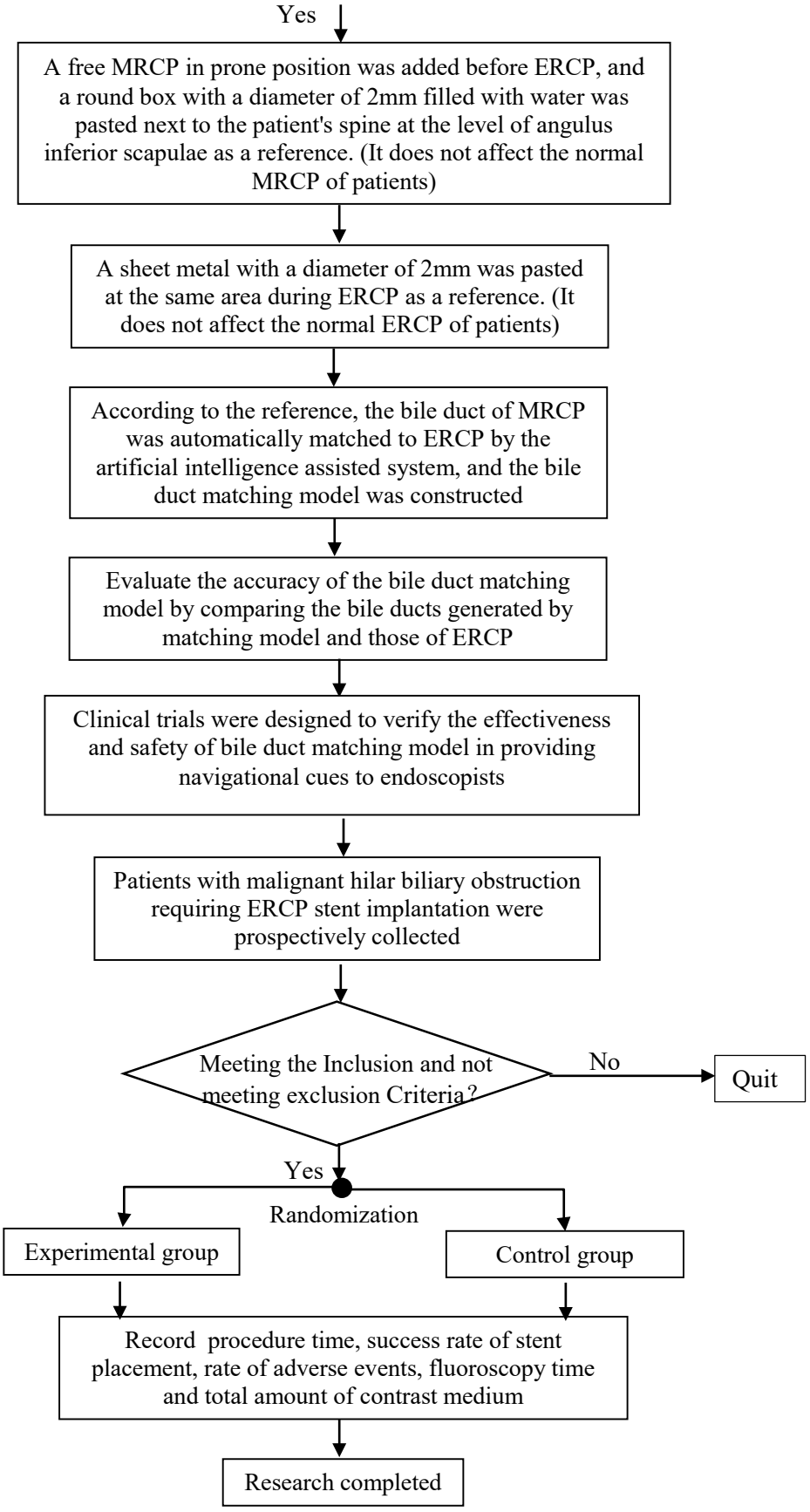
Security	Safety incidents shall be evaluated and reported according to the quality management measures for clinical trials of medical devices

1.1. Time and Event Tables

Events	Screening period （d -30~-1）	The day of ERCP(d 0）	Follow up (d 1-14)
Informed Consent	X		
Basic characteristics	X		
Medical history/surgical history	X		
Inclusion/Exclusion Criteria	X		
Random		X	
ERCP		X	
Concomitant treatment	X	X	
Concomitant medication	X	X	
Adverse Events		X	X
Research completed			X

1.2. Flow chat




Yes
A free MRCP in prone position was added before ERCP, and a round box with a diameter of 2mm filled with water was pasted next to the patient's spine at the level of angulus inferior scapulae as a reference. (It does not affect the normal MRCP of patients)
A sheet metal with a diameter of 2mm was pasted at the same area during ERCP as a reference. (It does not affect the normal ERCP of patients)
According to the reference, the bile duct of MRCP was automatically matched to ERCP by the artificial intelligence assisted system, and the bile duct matching model was constructed
Evaluate the accuracy of the bile duct matching model by comparing the bile ducts generated by matching model and those of ERCP
Clinical trials were designed to verify the effectiveness and safety of bile duct matching model in providing navigational cues to endoscopists
Patients with malignant hilar biliary obstruction requiring ERCP stent implantation were prospectively collected
Meeting the Inclusion and not meeting exclusion Criteria?
No
Quit
Yes
Randomization
Experimental group
Control group
Record procedure time, success rate of stent placement, rate of adverse events, fluoroscopy time and total amount of contrast medium
Research completed

2. Introduction

Biliary stricture can be divided into benign biliary stricture and malignant biliary stricture, and malignant hilar biliary obstruction is the one of the common cause. [1]Since there is no specific early screening method for malignant hilar biliary obstruction at present and most patients have no obvious clinical symptoms in the early stage, most patients are already in the advanced stage when they are first diagnosed. [2]Advanced malignant hilar biliary obstruction cannot undergo resection surgery, whose first choice for the treatment is palliative endoscopic biliary drainage. Biliary drainage can relieve jaundice, pruritus and other symptoms due to cholestasis.[3] However, before the narrow segment was placed the stent, the contrast agent could not pass through the narrow segment and the bile duct above the narrow segment could not be seen. So it was difficult for doctors to determine the direction of the guide wire and the position of the stent. In addition, indiscriminate application of the contrast agent may cause outflow obstruction leading to infection. However, there is no relevant research to solve these problems.

MRCP is the preferred examination method of pancreatic and bile duct diseases. [4,5]Therefore, MRCP should be routinely performed before patients are treated with ERCP. At present, MRCP is in supine position, and ERCP is in prone position. Different positions lead to differences in the morphology of MRCP and the bile duct on ERCP. So preoperative MRCP in supine position has limited role in advising physicians on the morphology of the bile duct. Therefore, MRCP in the prone position is more favorable for endoscopists to perform ERCP.

In recent years, deep learning algorithms have been continuously developed and increasingly mature. They have been gradually applied to the medical field. [6]Computer vision is a science that studies how to make machines "see". Through deep learning, camera and computer can replace human eyes to carry out machine vision such as target recognition, tracking and measurement. [7-9]Interdisciplinary cooperation in the field of medical imaging and computer vision is also one of the research hotspots in recent years. At present, it is mainly applied to the automatic identification and detection of lesions and quality control, and has achieved good results. It can assist doctors to find lesions, make disease diagnosis and standardize doctors' operations, so as to improve the quality of doctors' operations. [10-15]With mature technical support, it has a good prospect and application value to develop endoscopic operating system for lesion detection and quality control based on artificial intelligence methods such as deep learning.

In this study, the investigators proposed an artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP, which can instruct the direction of guide wire and the position of stent placement in real time.

3. Patient Selection

Male and female subjects aged 18 years or older will require MRCP and ERCP, and voluntarily provide imaging data of MRCP and ERCP, and sign an informed consent form.

Patients not meeting the inclusion criteria or meeting exclusion criteria will not be considered for participation in the study. Patients who met all criteria and singed informed consent may be excluded from the study due to:

• Endoscopists' professional advices/medical reasons (only under very limited conditions to avoid researcher bias).

• Withdraw informed consent.

3.1. Inclusion criteria

All patients meeting the following criteria will be considered for participation in the study:
1.Bile duct segmentation model
1) Male or female aged 18 or above;
2) Who needs ERCP, MRCP and its related tests are needed to further define the characteristics of digestive tract diseases;
3) The images of MRCP and ERCP are clear;
4) Able to read, understand and sign informed consent;
5) The investigator believes that the subject can understand the process of the clinical study and is willing and able to complete all the study procedures and follow-up visits and cooperate with the study procedures.

2.Bile duct matching model
In addition to the criteria mentioned in the bile duct segmentation model, the bile duct matching model should also meet the following criteria:
1) Able to complete MRCP in prone position;
2) Bile ducts are almost completely visible in MRCP and ERCP.

3.Clinical trials
In addition to the criteria mentioned in the bile duct segmentation model, the clinical trials should also meet the following criteria:
1) Able to complete MRCP in prone position;
2) Patients requiring biliary drainage by ERCP due to malignant hilar biliary obstruction.

3.2. Exclusion criteria

All patients meeting the following criteria will not be considered for participation in the study:
1.Bile duct segmentation model and bile duct matching model
1) Has participated in other clinical trials, signed the informed consent and was in the follow-up period of other clinical trials;
2) Drug or alcohol abuse or psychological disorder in the last 5 years;
3) Patients in pregnancy or lactation;
4) The investigator considers that the subjects were not suitable for MRCP, ERCP and related tests;
5) A high-risk diseases or other special conditions that the investigator considers inappropriate for the subject to participate in a clinical trial.

2.Clinical trials
In addition to the criteria mentioned in the above, the clinical trial must not meet any of the following criteria:
1) Previous gastrectomy;
2) Stent replacement;
3) Pyloric or duodenal obstruction.

3.3. Definition of enrollment

After participants signed informed consent, they were randomized before ERCP. The randomization time was the enrollment time, and was recorded in CRF.

4. Endpoints

4.1. Primary Endpoint

1) Procedure time: It was the time of performing ERCP.

4.2. Secondary Endpoints

1) Intersection over union of bile duct segmentation: It was the ratio of union and intersection of bile ducts predicted by artificial intelligence devices and actual bile ducts
2) Intersection over union of bile duct matching model: It was the ratio of union and intersection between the bile ducts generated by the AI device and the actual bile ducts in ERCP
3) Success rate of stent placement: It was calculated by dividing total number of patients with stent placement by the number of successful patients.
4) Rate of adverse events: It was calculated by dividing the total number of patients undergoing stent placement by the number of patients who experienced adverse events.
5) Fluoroscopy time: It was the sum of the total X ray fluoroscopy time during the whole procedure.
6) Total amount of contrast medium: It was the total amount of contrast medium during the whole procedure.

4.3. Safety evaluation endpoints and other secondary endpoints

Adverse events shall be determined according to the definition in the code for the quality management of adverse events of medical devices. The following types of adverse events should be recorded and calculated in the hospital history and CRF. According to the CRF table, the

occurrence time, starting and ending time, intervention measures and treatment results should be filled in when recording. The severity should be referred to the previous literature and CTCAE 5.0 standard.

5. Purpose and overall design

5.1. Purpose

The purpose of this study is to develop an artificial intelligence-based biliary stricture navigation system in MRCP-based ERCP, which can instruct the direction of guide wire and the position of stent placement in real time.

5.2. Overall design

This is a prospective, single-center, randomized controlled trial study.

6. Study process

6.1. Summary of Study Process

• If the patient meets the inclusion criteria, the patient is invited to participate in the study and then the informed consent procedure for the clinical trial is applied.
• Assess patients' eligibility based on the inclusion/exclusion criteria.
• If the patient meets the inclusion/exclusion criteria, information prior to ERCP will be collected
• If the patient is enrolled, he will be randomized
• ERCP is performed after informed consent. Any intraoperative adverse events are recorded on theCRF for submission and subsequent analysis.
• Follow-up will be performed from the postoperative to the study completion, as detailed in the time and event table.

6.2. Enrollment

Only after patients signed the informed consent, can the research-related procedures be conducted.

6.2.1. Informed Consent

According to the Helsinki Declaration, patients are not allowed to participate in the study without adequate informed consent. The principal investigator is responsible for ensuring that no patient was enrolled in the study without adequate informed consent. Failure to obtain informed consent and failure to document this process is considered a violation of the Helsinki Declaration and the study protocol.

All informed consent documents (ICDs) must be approved by ethics. Patient's informed consent requires documentary record on the informed consent by himself in his primary language.

The investigator or trained designated person performs a preliminary screening to determine if the patient generally meets the eligibility criteria for the study. If yes, the investigator or trained designee should recommend the patient to participate in the study. If the patient agrees to participate, they will need to sign an informed consent document.

The investigator or trained designated person should confirm that the subject understands the following points in the study:

- The purpose of research,
- Potential risks or adverse events,
- Potential risks or adverse events directly related to participating the research,
- The likelihood of failure,
- Research requirements include follow-up visits,
- All rights of the subject as a participant in the clinical study.

After explaining the purpose of the study, the investigator or trained designee should answer any questions from the subject. If the subject agrees to participate, his or her wishes must be recorded by signing and dated on the EC-approved ICF, and the document should be signed and dated by the patient receiving the informed consent.

After successful completion of the informed consent process, the investigator or trained designated person will assess the eligibility of patients based on the protocol.

6.2.2. Patient Selection

All patients who underwent ERCP, agreed to use EndoAngel and generally meet the study requirements were screened based on the inclusion/exclusion criteria. Patients who passed the screening were enrolled and recorded in the subject screening and enrollment tables. There is no bias in the choice of the enrolled subjects. The date of screening, the results (enrolled or not), and the primary reason for not selecting subjects (such as not meeting inclusion criteria, or not interested in participating in the study) will be recorded.

After the patients are enrolled, the research center should complete the preoperative study data collection.

It is desirable to be able to collect complete data for all enrolled patients, without who withdrawal from the study.

6.2.3 Subject identification number

Patients were numbered after signing informed consent.

The subject number begins with EA as a fixed number and is numbered starting from 0001 at the time of signing the informed consent. For example, the first patient who signed the informed consent was EA0001, and the second one was EA0002.

Once the subject identification number is assigned, the number is not reusable.

6.3 Treatment Description

This section applies to individuals who have signed an approved informed consent and have been identified as eligible to participate in this study on the basis of the inclusion and exclusion criteria. This section introduces the preoperative, surgical and postoperative management of subjects in detail.

6.3.1 Patient Screening Assessments

1） History
2） Physical examination
3） Hematuria pregnancy test (if required)

6.3.2 Pre-Procedure Managements

1） Fasting for 6 hours and water deprivation for 2 hours before examination
2） Routine stomach preparation.
3） Psychological counseling.
4） Performing routine anesthesia for painless gastroscopy patients.

6.3.3 Intraoperative Managements

1） Patient position: prone position with appropriate restraint.
2） Insertion route: according to the actual situation of the subject, usually through the esophagus
3） Routine observation

6.3.4 Post-operative Managements

1） Postoperative routine nursing
2） The anesthetized subjects were observed until they woke up, and the ordinary subjects were observed until they left the endoscopic room.
3） Record complications (if any).

6.4 Suspension and withdrawal

Patients who were screened and confirmed to be eligible for the study, signed the informed consent and completed the randomization were considered as enrolled. If serious program deviation, withdrawal, or death occurs, the subject study is considered to be suspended. If the subject discontinues the study after obtaining informed consent, the data before the discontinuation will still be included in the study-related analysis.

6.4.1Pre-Procedure

In any time during the study period, even before ERCP, participants could withdraw their informed consent whenever necessary. Researchers can withdraw participants before surgery according to safety considerations in the inclusion and exclusion criteria.

6.4.2 Intraprocedure

For safety reasons, the investigator may have the subject quit during the procedure. For example, the patient is not suitable for receiving the instrument for the study or the endoscopists do not use the specified instrument for any reason. If the following serious cases occur, please withdraw during the operation:

1） Perforation
2） Bleeding
3） Allergy to narcotic drugs
4） Unable to complete ERCP due to obstruction or other reasons

6.4.3 Replacement

Subject will be deemed to have commenced the study upon completion of the informed consent process, and any subject who has been discontinued prior to or during the ERCP will not subsequently be replaced by other subjects.

6.5 Randomization and Blinding

6.5.1 Randomization Implementation

Randomization is conducted according to the study protocol, and the random contents are implemented in an electronic system block-randomized manner (n = 4; experimental group/control group = 1). Randomization prior to ERCP to decide whether to use EndoAngel. The researchers randomized the random results generated by the electronic system, and the generated random results were stored in the research center. The random time (accurate to minute), random person, subject number and acronym were recorded in the corresponding positions of the electronic system.

6.5.2 Blinding Implementation and Protection

Subjects and evaluators are blinded according to the protocol.

Randomization results will be kept confidential to the subjects in general. Randomization results are not reflected in inpatient history and other subject access documents. During and after the examination, study personnel should take care not to talk to the subject about the results of the randomization to avoid unnecessary unblinding

The assessors are blinded, and the data analysis team and pathologists could not obtain the randomization results from the medical history data.

6.5.3 Unblinding

Uncovering or breaking the blindness means displaying the randomized results to the subjects or evaluators. Researchers should protect the blind method as far as possible. Uncovering the randomized results of a single subject may lead to the leakage of the randomized results of other subjects. Any leakage of the randomized results will have a significant impact on statistical analysis. In general, it is prudent to deal with the disclosure of blind law. In the following cases, it is possible to consider the disclosure of blind law:

1) endangering the safety of subjects: For example, in some serious adverse events, subjects need to know the randomized results to inform other physicians to take appropriate emergency treatment.
2) Threatening the safety of the assessor: When the assessor is facing potential safety hazards, he needs to know the randomization results.
3) Compliance: For reasons of partial compliance, in certain circumstances, if the research instruments and cases involved in unexpected adverse events are needed, the results of randomization should be made public to the relevant departments or the public.
5) Other management reasons.

6.6 Concomitant therapy and medication

The concomitant treatment and concomitant medication were recorded from the time the subject signed the informed consent to the time the study was completed. Concomitant treatment and concomitant medication should be recorded in the CRF, or a clear copy of the form available from the research center should be kept in the CRF as research data to identify other factors affecting the end of the study. When recording the concomitant treatment and concomitant medication, the indications and the starting and ending time of use should be clearly defined, and the corresponding types of adverse events should be indicated for the treatment measures to cope with adverse events. When using a copy of the study center form, the investigator should sign the copy and indicate the date of review to confirm that the document is a study document.

7. Basis of study protocol and risk/benefit analysis

EndoAngel is used to provide assistant to monitor the operation of endoscopists, which will not provide diagnosis. Doctors make their own diagnosis on the basis of EndoAngel's results. The security of the software and the improvement of endoscopic physician's diagnosis and treatment level have also been confirmed in the previous feasibility study. And the patients in this study carry out the diagnosis and treatment according to the conventional treatment measures, which are formulated in accordance with the standard medical treatment procedures and do not increase the risk of the subjects.

7.1. Selection of endpoints

The primary endpoint is the procedure time.

The secondary endpoints were:1) Intersection over union of bile duct segmentation;2) Intersection over union of bile duct matching model;3) Success rate of stent placement;4) Rate of adverse events;5) Fluoroscopy time;6) Total amount of contrast medium.

Adverse events in safety indicators shall be judged in accordance with relevant regulations, and serious adverse events shall be recorded and reported in accordance with regulations.

Other evaluations are detailed in the Case Report Form (CRF).

7.2. Definition of participants

Patients were included according to the indications and contraindications described in the use

plan. Because of practical reasons (such as younger patients, participation in a number of clinical studies, alcohol/drug dependence patients, and other factors that may affect the completion and/or reliability of gastroscopy) and ethical reasons (whether informed consent can be completed, etc.), the entry and discharge criteria have been reduced.

7.3. Adverse events

The relevant definitions of adverse events are as follows:

Adverse Events (AE): Any adverse medical event, unexpected disease or injury, or adverse clinical manifestations (including abnormal laboratory findings) that occur in a subject, user or other person, whether or not associated with medical devices.

Serious Adverse Events (SAE): Adverse Events with the following information:
- causing death.
- leading to severe deterioration of the health of the subjects, including
- leading to life-threatening diseases or injuries,
- Causing impairment of body structure or function.
- Need hospitalization or extended hospitalization
- lead to hospitalization and preventive medical or surgical intervention
- Permanent damage to body structure or function
- Fetal distress, fetal death or congenital abnormalities or congenital defects.

Note: Hospitalization for existing conditions, or surgery required in the program, without serious deterioration of health status, is not considered a serious adverse event. Purposeful hospitalization, such as economic or reimbursement reasons, is not considered a serious adverse event.

Unexpected adverse device response (UADE): refers to adverse events related to medical devices that were not previously identified in the current version of the risk analysis report in terms of nature, severity or incidence. The definition includes any event caused by insufficient or inadequate description of the use or deployment of the device. This definition includes any event caused by a user's error.

7.4. Expected and trial-related adverse events

Previous studies have shown that the expected adverse events are basically the same as the complications of conventional endoscopic diagnosis and treatment.

The instrument used in this experiment is a medical software which is not in contact with human body. There is no difference between the experimental operation and the routine operation. The intervention measures (such as randomized process) in the experiment may slightly increase

the incidents of diagnosis and treatment.

7.5. Risk minimization

In this study, when there are bugs in the software, doctors can still operate under their own judgment without affecting conventional diagnostic and treatment measures, greatly reducing the risk of the test.

7.6. Related benefits

Subjects will be randomly assigned to an experimental group or a control group. And experimental subjects may improve the quality of ERCP.

7.7. Overall feasibility analysis

EndoAngel is an independent system including both software and computer hardware, which can monitor image data 24 hours a day. The system is not invasive. The overall operability is strong.

8. Statistical Analysis

8.1. Statistical Analysis Plan

Data management and statistical analysis were implemented by Renmin Hospital of Wuhan University.

8.2. Methods

Continuous variables should be described by number of subjects, mean, standard deviation, median, minimum and maximum. The classification variables are summarized by frequency and percentage.

8.3. Hypothetical test

The main assumptions are:

1.The use of EndoAngel can reduce the operation time of ERCP;
2.The use of EndoAngel can improve the success rate of stent placement;
3. The use of EndoAngel can reduce the rate of adverse events;
4. The use of EndoAngel can reduce the fluoroscopy time;
5. The use of EndoAngel can reduce the total amount of contrast medium.

8.4. Sample Size Calculation

We mainly studied the effect of EndoAngel on the quality of ERCP for physicians. Therefore, data collection and analysis were conducted for the main effect. It is expected that a total of 62 subjects will be enrolled. Assuming the operation time of ERCP in experimental group is 43.9±11.56 minutes, the operation time of ERCP in control group is 35 minutes. Bilateral significance level 5% (alpha =5%), assurance 80% (beta =20%), shedding rate 10%, Expected to enroll 62 patients in total.

8.5. Statistical analysis set

All patients who met the inclusion and exclusion criteria were considered eligible for recruitment.

The two analysis sets in this study are defined as follows:

• The full analysis set (FAS) population analysis set will contain all eligible cases and shedding cases, but does not include culling cases.

• The Compliance (PP) population analysis set will include all subjects in the FAS analysis set with no significant deviation from the program.

Intention-to-treat and conformity analysis sets should be used to analyze the primary efficacy endpoints. The main analysis will be based on the PP analysis set. FAS analysis was regarded as supportive analysis.

9. Device Description

EndoAngel
Version: EA 2301

10. Abbreviations

Abbreviations	Full Name	Chinese
AE	Adverse Event	不良事件
CFDA	China Food and Drug Administration	国家食品药品监督管理总局
CNDA	China National Drug Administration	国家食品药品监督管理总局
CRF	Clinical Record File	病例报告表
CTCAE	Common Terminology Criteria for Adverse Events	不良事件常规评价标准
EC	Ethical Committee	伦理委员会
ICD	Informed Consent Document	知情同意文件
ICF	Informed Consent Form	知情同意书

ITT	Intention to Treat	意向治疗分析集
PP	Per Protocol	符合方案集
SAE	Serious Adverse Event	严重不良事件
ERCP	Endoscopic Retrograde Cholangiopancreatography	经内镜逆行性胰胆管造影术
MRCP	Magnetic Resonance Cholangiopancreatography	磁共振胰胆管造影

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Informed Consent Form

"Development and Validation of an Artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP"

Informed Consent Form for clinical study subjects

Informed Consent Form: Information page

Release date: 1.2,13 April 2021

Principal investigator: Yu Honggang

Dear sir / Madam,

We will invite you to participate in a clinical study "Development and Validation of an Artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP". During this study, we will use a new ERCP-assisted system which do not interfere the physician's original observations and procedures.

Before you decide whether to participate in the study, please read the following as carefully as possible to help you understand the study and why it was conducted, the procedure and duration of the study, the potential benefits or risks of participating in the study. If you wish, you can discuss it with your family or friends, or ask your doctor for an explanation to help you make a decision

1. Background and Purpose

Biliary stricture can be divided into benign biliary stricture and malignant biliary stricture, and malignant hilar biliary obstruction is the one of the common cause. Since there is no specific early screening method for malignant hilar biliary obstruction at present and most patients have no obvious clinical symptoms in the early stage, most patients are already in the advanced stage when they are first diagnosed. Advanced malignant hilar biliary obstruction cannot undergo resection surgery, whose first choice for the treatment is palliative endoscopic biliary drainage. Biliary drainage can relieve jaundice, pruritus and other symptoms due to cholestasis. However, before the narrow segment was placed the stent, the contrast agent could not pass through the narrow segment and the bile duct above the narrow segment could not be seen. So it was difficult for doctors to determine the direction of the guide wire and the position of the stent. In addition, indiscriminate application of the contrast agent may cause outflow obstruction leading to infection. However, there is no relevant research to solve these problems.

MRCP is the preferred examination method of pancreatic and bile duct diseases. Therefore, MRCP should be routinely performed before patients are treated with ERCP. At present, MRCP is in supine position, and ERCP is in prone position. Different positions lead to differences in the morphology of MRCP and the bile duct on ERCP. So preoperative MRCP in supine position has limited role in advising physicians on the morphology of the bile duct. Therefore, MRCP in the prone position is more favorable for endoscopists to perform ERCP.

In recent years, deep learning algorithms have been continuously developed and increasingly mature. They have been gradually applied to the medical field. Computer vision is a science that studies how to make machines "see". Through deep learning, camera and computer can replace human eyes to carry out machine vision such as target recognition, tracking and measurement. Interdisciplinary cooperation in the field of medical imaging and computer vision is also one of the research hotspots in recent years. At present, it is mainly applied to the automatic identification and detection of lesions and quality control, and has achieved good results. It can assist doctors to find lesions, make disease diagnosis and standardize doctors' operations, so as to improve the quality of doctors' operations. With mature technical support, it has a good prospect and application value to develop endoscopic operating system for lesion detection and quality control based on artificial intelligence methods such as deep learning.

In this study, the investigators proposed an artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP, which can instruct the direction of guide wire and the position of stent placement in real time.

2. Who can participate in the study

2.1. Bile duct segmentation model

1) Male or female aged 18 or above;

2) Who needs ERCP, MRCP and its related tests are needed to further define the characteristics of digestive tract diseases;

3) The images of MRCP and ERCP are clear;

4) Able to read, understand and sign informed consent;

5) The investigator believes that the subject can understand the process of the clinical study and is willing and able to complete all the study procedures and follow-up visits and cooperate with the study procedures.

2.2. Bile duct matching model

In addition to the criteria mentioned in the bile duct segmentation model, the bile duct matching model should also meet the following criteria:

1) Able to complete MRCP in prone position;

2) Bile ducts are almost completely visible in MRCP and ERCP.

2.3. Clinical trials

In addition to the criteria mentioned in the bile duct segmentation model, the clinical trials should also meet the following criteria:

1) Able to complete MRCP in prone position;

2) Patients requiring biliary drainage by ERCP due to malignant hilar biliary obstruction.

3. Who can not participate in the study

3.1. Bile duct segmentation model and bile duct matching model

1) Has participated in other clinical trials, signed the informed consent and was in the follow-up period of other clinical trials;
2) Drug or alcohol abuse or psychological disorder in the last 5 years;
3) Patients in pregnancy or lactation;
4) The investigator considers that the subjects were not suitable for MRCP, ERCP and related tests;
5) A high-risk diseases or other special conditions that the investigator considers inappropriate for the subject to participate in a clinical trial.

3.2. Clinical trials
In addition to the criteria mentioned in the above, the clinical trial must not meet any of the following criteria:
1) Previous gastrectomy;
2) Stent replacement;
3) Pyloric or duodenal obstruction.

4. What would you need to do

Patients need to prepare for ERCP routinely, fasting for at least 6 hours and water deprivationfor at least 2 hours before the procedure. Patients undergoing painless operation receive general anesthesia, while patients undergoing general operation do not need it. If you are assigned to the experimental group, the endoscopists will be assisted by EndoAngel, which can instruct the direction of guide wire and the position of stent placement in real time. If you are assigned to the control group, the endoscopist performs ERCP routinely without specialprompts. You are equally likely to be in the above two groups.

5. Benefits

You will be randomized into the experimental group and the control group. The endoscopists in the experimental group will be assisted by EndoAngel, which can assist in instructing the direction of guide wire and the position of stent placement in real time. Patients who have access to the ERCP with EndoAngel will likely have fewer surgical times, higher surgical success rates, and lower incidences of adverse events.

6. Adverse events

The adverse events are basically the same as the complications of conventional endoscopic diagnosis and treatment. Participants in this study do not increase other additional risks.

7. Related fees

Routine MRCP and ERCP for your clinical examination items, the cost of your own. Additional MRCP in prone position is free.

8. Personal Information

During the MRCP and ERCP process, your electronic images and case information will be

collectedand preserved in the hospital. Your doctor, the researcher, will be given access to this electronic information for scientific research. Your personal identity will not be disclosed in any public report of the results of the relevant research and development. We will do everything within the law to protect the privacy of your personal medical data.

9. For more information

You can ask any question about this study at any time.

Your doctor will give you his or her phone number so that he or she can answer your questions

Your doctor will keep you informed if there is any important new information during the course of the study that may affect your willingness to continue participating in the study.

10. Participation and withdrawal are voluntary

Participation in the study is entirely up to you. You may refuse to participate in the study or withdraw from the study at any time during the course of the study. You will not be discriminated against or retaliated against for refusing to participate in the study. Your medical treatment and entitlements will not be affected.

Your doctor or researcher may suspend your participation at any time in the best interest of you.

If you withdraw from the study for any reason, you may also be required to undergo a laboratory and physical examination if your doctor deems it necessary.

If you choose to participate in this study, we hope that you can adhere to the completion of the entire research process.

11. Others

Participating in this study is up to you. You can discuss it with your family or friends before making a decision.

Before you decide to participate in the study, ask your doctor as many questions as you can about the study until you have a complete understanding of it.

Thank you for reading this. If you decide to participate in the study, please tell your doctor, he or she will arrange for you to participate in all matters related to the study.

Please keep this information.

Informed Consent Form: Information page

Name of Clinical Research Project: Development and Validation of an Artificial Intelligence-based Biliary Stricture Navigation System in MRCP-based ERCP

Research physician commitment:

As a research physician, I confirmed that I had clearly explained to the subject the details of this trial, including their rights and possible benefits and risks, and gave them a signed copy of my informed consent.

Name：_____ Date: _____

Contact：_____

Subject commitment:

I have read and understood the introduction to this study on the informed consent page, and have had the opportunity to ask questions. I understand the research physician's explanation.

I am aware of the risks and benefits of participating in this study. I am aware that participation in the study is voluntary, and I am sure that there has sufficient time to consider and volunteer for the trial. I can always ask my doctor for more information, and I can always withdraw from the study without discrimination or retaliation, and without prejudice to medical benefits and entitlements.

I also knew that if I dropped out of the study, I would tell my doctor and complete the physical and chemical tests. If I need to take any other medication for my illness, I will consult with my doctor in advance or tell him the truth afterwards.

I agree☐ or refuse☐ Use my medical records for any other study.

I agree to participate in the study and promised to follow the doctor's advice to the best of my ability. I will receive a signed and dated copy of the Informed Consent Form.

Name：_____ Date: _____

Contact：_____

-End-