Trials

STUDY PROTOCOL

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Efficacy and safety evaluation of a reusable advanced hemostatic device (Vi-Sealer) during total laparoscopic hysterectomy in South Korea (KGOG4009/Vi-TLH trial): study protocol for a multicenter, open-label, non-inferiority randomized controlled trial

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Abstract

Background Advanced hemostatic devices (AHDs) are widely utilized in gynecologic minimally invasive surgeries. These AHDs control ultrasonic or bipolar electric/thermal energy with a feedback mechanism and effectively seal vessels without thermal spread. However, most AHDs are single-use, potentially increasing surgical costs. Vi-Sealer, a reusable AHD with an interchangeable blade, aims to address this issue. This study assesses operative outcomes and complications to evaluate the efficacy and safety of Vi-Sealer compared to other AHDs.

Methods This multicenter, open-label, non-inferiority, randomized controlled trial compares Vi-Sealer with other AHDs in 280 patients undergoing total laparoscopic hysterectomy (TLH) for benign gynecologic diseases, assuming a 25-min (20%) non-inferiority margin in operative time. Cases with uterine or preinvasive cervical pathology were included, while those with huge tumor size were excluded. Participants are stratified into two cohorts based on competing devices. Each cohort consists of 140 participants, randomized in a 1:1 ratio to undergo TLH with either Vi-Sealer or a comparator device—LigaSure in cohort 1 and other AHDs in cohort 2. This study will be conducted at university-affiliated hospitals in South Korea, where recruitment will be carried out within the gynecology clinics. The enrollment is planned to begin in November 2022. Participants will be blinded, whereas surgeons will not be due to the nature of surgery. The primary endpoint is operation time (min) defined as the duration of the initial skin incision to the completion of skin closure, while secondary endpoints include blood loss (mL), medical cost (won), operating surgeons' device function scores, and adverse events. Outcomes will be analyzed separately for each cohort. Adverse events and complications will be assessed clinically until postoperative follow-up, per CTCAE. This trial is currently in the recruitment phase with active enrollment ongoing.

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Discussion This study will evaluate the efficacy, safety, and cost analysis of the reusable Vi-Sealer in TLH. Through the comparison of AHDs, this is expected to provide robust evidence to determine whether the Vi-Sealer is non-inferior to disposable AHDs.

Trial registration This study was registered on ClinicalTrials.gov (NCT05629611) on November 29, 2022 (https://clinicaltrials.gov/study/NCT05629611?intr=vi-sealer&rank=1) and cris.nih.go.kr (KCT0008008) on December 13, 2022 (https://cris.nih.go.kr/cris/search/detailSearch.do?seq=23737&search_page=L). This is currently open for enrollment.

Keywords Advanced hemostatic devices, Advanced energy devices, Minimally invasive surgery, Laparoscopic total hysterectomy, Female gynecologic disease

Administrative information

Note: the numbers in curly brackets in this protocol refer to SPIRIT checklist item numbers. The order of the items has been modified to group similar items (see http://www.equator-network.org/reporting-guidelines/spirit-2013-statement-defining-standard-protocol-items-for-clinical-trials/).

Title {1}	Efficacy and safety evaluation of a reusable advanced hemostatic device (Vi-Sealer) during total laparoscopic hysterectomy in South Korea (KGOG4009/Vi-TLH trial): study protocol for a multicenter, open-label, non-inferiority randomized controlled trial
Trial registration {2a and 2b}	This study was registered on ClinicalTrials.gov on November 29, 2022 (NCT05629611) and cris.nih.go.kr on December 13, 2022 (KCT0008008). This is currently open for enrollment
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Name and contact information for the trial sponsor {5b}	This is an investigator initiated trial; H. Park (principal investigator), p06162006@cha.ac.kr
Role of sponsor {5c}	In this study, funder has no role in study design, collection, management, analysis, and interpretation of data and in writing of the report

Introduction

Background and rationale {6a}

Hysterectomy is a common surgical procedure for gynecologic diseases, though its incidence has slightly declined [1, 2]. In the USA, more than 400,000 hysterectomies were performed annually as of 2010. A surgery assessing age-standardized prevalence reported that 17.9% of adult women had undergone a hysterectomy, with a higher prevalence among women aged 70 years or older [2]. The laparoscopic approach to hysterectomy has seen a steady increase [3, 4]. According to Tyan et al., the rate of laparoscopic hysterectomies rose from 26.5% in 2007 to 65.6% in 2016, while the rate of abdominal hysterectomies decreased from 54.3% to 23.1% over the same period. Similar figures have been reported in South Korea. The overall rate of hysterectomy was 1.49 per 1000 women, and a laparoscopic approach was used in 52.0% of cases in 2009 [5]. Compared to abdominal hysterectomy, laparoscopic hysterectomy offers cosmetic advantages and allows for a quicker return to normal activities [6].

Energy-based devices are considered essential for the completion of laparoscopic surgery. For decades, monopolar and bipolar systems were the only options available. Surgeons have expressed concerns about the risks of lateral thermal damage and the effectiveness of sealing vascular bundles encountered in gynecologic surgery [6]. Advanced hemostatic devices (AHDs) have been developed to overcome these limitations. The currently available AHDs can be categorized into three main types based on their energy sources: electrothermal bipolar energy, ultrasonic energy, and hybrid systems. Electrothermal bipolar energy devices use high current, low-voltage continuous bipolar energy and pressure between the jaws, resulting in the fusion of vessel collagen and elastin. Ultrasonic devices use mechanical vibrational energy to denature the proteins in tissues, sealing the vessels [7]. These devices can safely seal vessels up to 7 mm in diameter and minimize heat damage to surrounding tissues [7–9].

Previous studies have shown that AHDs are associated with better outcomes, including up to a 25% reduction in operation time and up to a 30% decrease in estimated

blood loss, compared to conventional bipolar devices in minimally invasive gynecologic surgeries [7, 10–12]. However, due to potential risks of infection and device failure, most medical device manufacturers supply AHDs as single-use items. Single-use medical devices can increase medical costs and contribute to environmental pollution [13, 14]. Developing a reusable AHD is crucial to addressing both economic and environmental concerns, while still ensuring high performance and safety.

Objectives {7}

Vi-Sealer (Zerone, Korea) is a reusable advanced bipolar electrode with an interchangeable blade. This device can effectively seal and cut vessels without the need to switch devices, functioning similarly to current AHDs. The primary objective of this study is to evaluate the efficacy of Vi-Sealer by comparing operative procedure time with other AHDs, such as LigaSure, during total laparoscopic hysterectomy (TLH) for benign gynecologic neoplasms. The secondary objective is to assess the safety of Vi-Sealer by measuring intraoperative blood loss and to conduct an economic evaluation compared to other disposable devices.

Trial design {8}

Vi-TLH is a multicenter, open-label, non-inferiority randomized controlled trial aimed at investigating the efficacy, safety, and cost analysis of Vi-Sealer compared to standard AHDs in TLH for benign gynecologic disease. This parallel study involves randomly assigning patients in a 1:1 ratio to either the Vi-Sealer group or the comparator AHD group. Participants are stratified into two cohorts (cohorts 1 and 2) based on the comparator devices (Fig. 1). The first cohort aimed to enable a direct comparison with LigaSure, given its status as a representative AHD. In contrast, the second cohort was designed to reflect the diversity of AHDs used in routine clinical settings.

Surgeons may be allocated to different devices during the study. However, TLH is one of the most commonly performed gynecologic procedures, and we believe that inter-surgeon variability is minimal among gynecologists. To further reduce potential bias, cases with higher surgical complexity are excluded, and a standardized surgical protocol is implemented to ensure consistency across all operative steps.

Methods: participants, interventions and outcomes

Study setting {9}

To participate in the KGOG4009/Vi-TLH trial, institutes should be active members of the Korean Gynecologic Oncology Group (KGOG) that has run a list of trials for gynecologic tumors and provided evidence to establish practice guidelines [15]. Patient registration and clinical trial will be conducted at eight university-affiliated hospitals as follows: CHA Bundang Medical Center, CHA University; CHA Gangnam Medical Center, CHA University; Women's Cancer Center, Yonsei University; Kyungpook National University Chilgok Hospital, Kyungpook National University; Seoul National University Bundang Hospital, Seoul National University; Kangbuk Samsung Hospital, Sungkyunkwan University; Kangnam Sacred-Heart Hospital, Hallym University; Seoul St. Mary's Hospital, The Catholic University of Korea. The populations at the participating centers are considered representative of the target population, as these centers manage a broad spectrum of benign gynecologic conditions.

Eligibility criteria {10}

Inclusion criteria

Patients should meet all of the following criteria to participate.

1. Women aged 20 to 65 years
2. Patients with clinically diagnosed benign or preinvasive gynecologic disease
3. Patients eligible for TLH (e.g., uterine diseases such as fibroids, adenomyosis with or without adnexal pathology)

Exclusion criteria

Patients who meet any of the following criteria cannot participate.

1. Patients with a uterus size equivalent to over 16 weeks of gestational age
2. Diagnosed cervical or intraligamentary fibroids
3. Severe endometriosis (stage 3 or 4)
4. Suspected malignancy of the uterus or adnexa
5. Contraindications for the use of energy devices (e.g., implantable cardioverter defibrillators, pacemakers)
6. History of more than three previous pelvic surgeries
7. Unsuitability for laparoscopic surgery

Who will take informed consent? {26a}

If patients are interested in trials, they are screened by dedicated research staff. Potential participants will be given detailed information about the study. After full understanding, informed consent will be gained by attending physicians. The consent form includes the study background, randomization methods, surgical

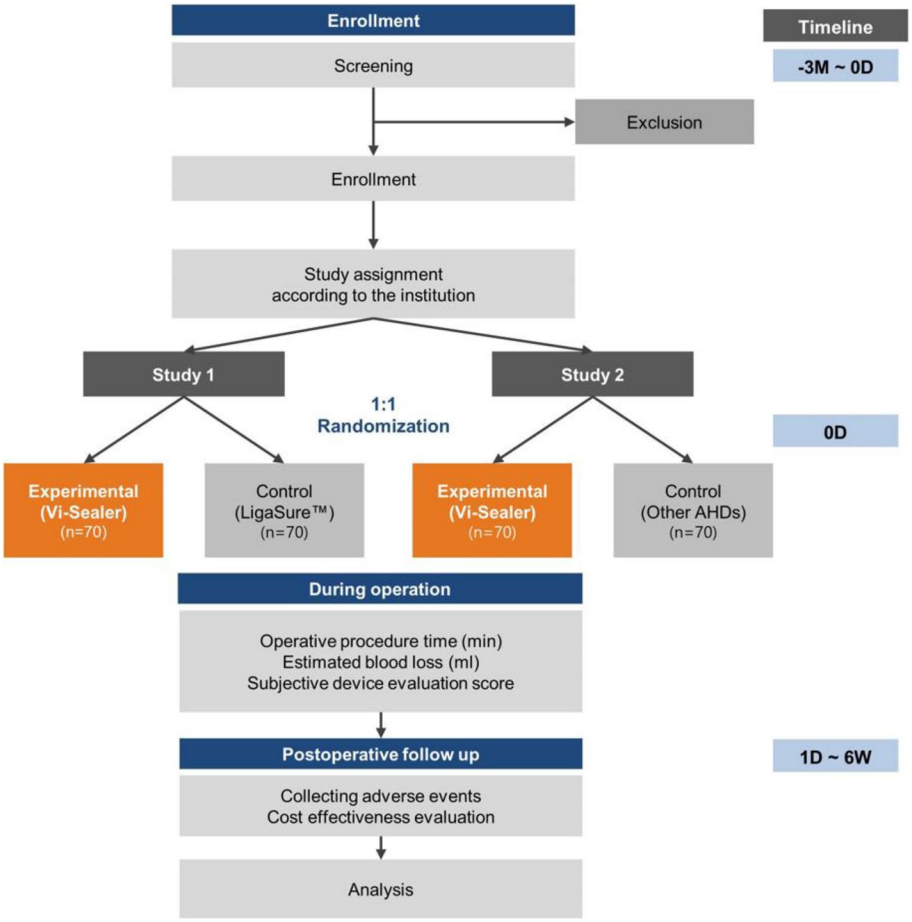

Fig. 1 Flow diagram of trial

steps, collection and provision of data, and confidentiality of collected data.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

There are no additional consent provisions.

Interventions

Explanation for the choice of comparators {6b}

After registration, participants are stratified into two cohorts for randomization. In cohort 1, a head-to-head comparison is conducted between Vi-Sealer and LigaSure™ (Medtronic, Minneapolis, MN, USA), a market-leading AHD selected as a standard comparator in multiple randomized controlled trials (RCTs). LigaSure offers the advantage of being disposable, which helps minimize contamination risks compared to reusable devices like the Vi-Sealer. In cohort 2, various AHDs with different energy sources are allowed as comparators, including THUNDERBEAT® (Olympus Medical Systems Corp., Tokyo, Japan), Harmonic (Ethicon, Inc., USA), and ENSEAL (Ethicon Endo-Surgery, USA), provided they are for single-use (Fig. 2).

Intervention description {11a}

The experimental device, Vi-Sealer (Zerone, Gyeonggi-Do, Korea), is an advanced bipolar energy device certified by the National Institute of Medical Device Safety Information in Korea. It features a bipolar electrode tip with an exchangeable blade and is assembled in five steps. The device is reusable after disinfection and sterilization, except for the single-use blade. It connects to the energy generator unit (Zeus Prime, Zerone, Gyeonggi-Do, Korea), which allows adjustment of coagulation intensity and time across five levels (Fig. 3).

Given that the participating surgeons are already familiar with AHD, hands-on practice with the Vi-Sealer will be conducted during the investigator meeting using porcine tissue or equivalent models. The assembly process of the reusable Vi-Sealer will also be demonstrated at the meeting. To ensure consistent and repeatable training, an

Fig. 2 Various ADHs currently in use with enlarged views of the jaws. **A** LigaSure™ (Medtronic, Minneapolis, MN, USA), utilizing bipolar energy; **B** Harmonic (Ethicon, Inc., USA), utilizing ultrasonic energy; **C** THUNDERBEAT® (Olympus Medical Systems Corp., Japan), utilizing hybrid bipolar and ultrasonic energy; **D** ENSEAL (Ethicon Endo-Surgery, USA), utilizing bipolar energy

instructional video has been produced and is available at https://www.youtube.com/watch?v=VAXOxA7De5Y.

Surgical procedures

TLH is performed according to standard hysterectomy procedures. The surgery begins with the adnexa. In cases where salpingo-oophorectomy is performed, the infundibulopelvic ligament is ligated and cut. Otherwise, the ovarian ligament and tubal isthmus are coagulated, ligated, and cut first. The broad ligament is then divided, and the uterine vessels are skeletonized at the level of the uterine isthmus and ligated. Following this, a colpotomy is performed. The uterus is removed through the vagina or abdomen, and the vaginal cuff is subsequently closed.

In the test group, the Vi-Sealer with an interchangeable blade is used for dissection, hemostasis, and transection of the adnexa (ovarian ligament and fallopian tube or infundibulopelvic ligament), round ligament, broad ligament, and uterine vessels, as well as for bleeding control after the colpotomy. In the control group, LigaSure (cohort 1) or other AHDs (cohort 2) are used for the same surgical procedures. The monopolar electrode is used for creating the bladder flap or performing the colpotomy.

Criteria for discontinuing or modifying allocated interventions {11b}

The allocated intervention will be discontinued if severe adhesions are noted in the surgical field and adhesiolysis takes more than 15 min. In the event of intraoperative discontinuation, patients will receive standard care, either through minimally invasive surgery or open surgery, depending on the surgical findings. Participants may also withdraw from the study at any time, without providing a specific reason, if they wish. Additionally, if a participant does not comply with the study procedures, the investigator has the authority to exclude them from the study. It is expected that participants adhere to the study schedule to ensure the timely completion of assessments. Compliance will be monitored through direct observation.

Strategies to improve adherence to interventions {11c}

In this study, approved ADHs currently used in the surgical theater will be utilized. Aside from the use of ADHs, the surgical process will adhere to the standard TLH method. ADHs are generally considered superior to conventional monopolar or bipolar electrodes in terms of surgical outcomes. Therefore, a high level of participant engagement in the study is anticipated.

Relevant concomitant care permitted or prohibited during the trial {11d}

Concomitant adnexal surgeries such as salpingo-oophorectomy, ovarian cystectomy, and salpingectomy are allowed alongside TLH during the trial.

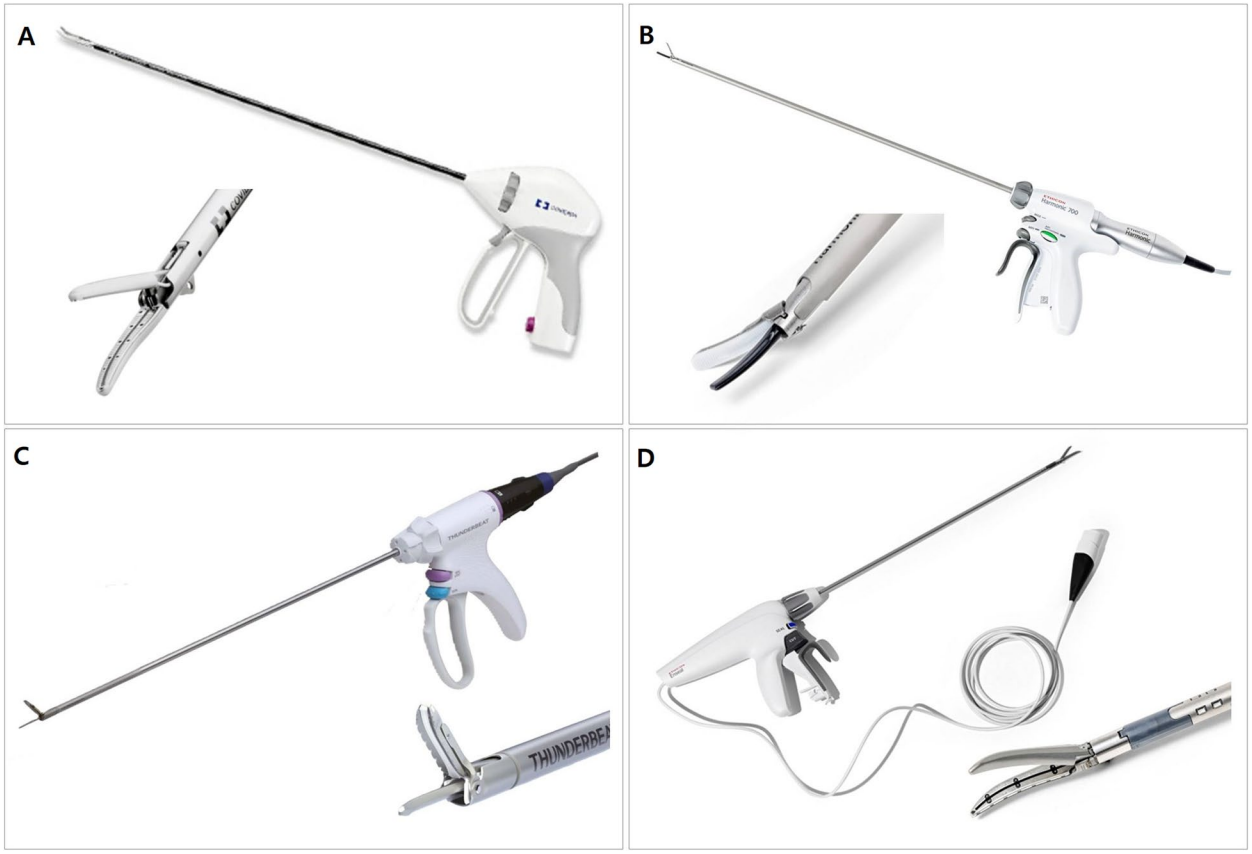

Fig. 3 Vi-Sealer as a reusable ADH. An enlarged view of the jaw shows the reusable blade mounted in place

Provisions for post-trial care {30}

KGOG, serving as the coordinating center for the study, will have insurance in place to cover any adverse events (unexpected complications or injuries) that occur during the study. If such events are determined to be caused by activities related to the study, the insurance will provide compensation or coverage for the damages incurred. The investigators will assess the causal relationship between adverse events and the investigational medical devices based on the WHO-UMC system.

Patients and public involvement

Patients or members of the public will be actively involved in the design, conduct, and reporting of the trial. During the design phase, patients with the relevant condition will be invited to share their perspectives and help shape the study design. In the conduct phase, surveys will be administered to participants or their representatives to gather feedback and adjust the study procedures accordingly. For the reporting phase, in addition to presenting findings at academic conferences for experts, the results will also be shared at a public research outcome forum hosted by the Korea Health Industry Development Institute (KHIDI). The final results will also be accessible through the official website of the coordinating center, KGOG.

Outcomes {12}

The primary outcomes are operative procedure time (min). Operative procedure time is defined as the duration from the initial skin incision to the closure of abdominal trocar sites. To specifically measure the time for operating devices, this will be segmented and recorded into three subcategories: T1 is the time from the first use of AHD to securing the uterine vessels; T2 is from the first use of AHD to achieving hemostasis of the vaginal cuff after colpotomy; and T3 is the time required for vaginal cuff suturing, from the moment the needle is first seen to cutting out the thread.

The secondary outcomes include blood loss, cost analysis, and device evaluation scores assigned by surgeons. Intraoperative blood loss (mL) will be calculated by subtracting the volume of irrigation fluid remaining in the bottle from the total volume in the suction canister. Additionally, perioperative changes in hemoglobin levels (g/dL) will be measured for each patient. To evaluate cost

analysis, total medical costs (KRW), including those for the operation, anesthesia, hospital stay, and perioperative care, will be collected over the study period. Surgeons will provide subjective scores on the hemostatic ability and maneuverability of the devices using a 5-point scale (1 = very dissatisfied, 5 = very satisfied) for four items immediately after each procedure (Supplementary 1).

Adverse events related to the medical devices used in the clinical trials will also be collected and recorded.

Participant timeline {13}

See Table 1.

Sample size {14}

This non-inferiority study focuses on operation time as the primary outcome. The sample size calculation is based on previous studies comparing AHDs in laparoscopic hysterectomy. The expected mean operation time is 120 min with a standard deviation of 48 min (40%). Assuming a non-inferiority margin in operation time of 25 min (20%) and a drop-out rate of 10%, with 1:1 randomization, a significance level of $\alpha = 0.025$ (one-sided), and a type II error (β) of 0.2 (i.e., power = 80%), 70 patients are required for each group. This results in a total of 140 patients per cohort and 280 patients overall. A 25-min (20%) difference in operation time during TLH is regarded as clinically insignificant and has been employed as a non-inferiority margin in prior comparable studies.

Table 1 Time schedule outline of study procedure and assessment

Visit type	Screening	Operation/ treatment	Follow up
Timeline	−3M~−1D	0D	1D~6W
Window period	–	–	+6W
Informed consent	O		
Screening and enrollment	O		
Demographic questionnaires	O		
History taking	O		
Physical exam	O		
Pregnancy test	O		
Inclusion/exclusion criteria	O		
Randomization		O	
Surgical procedure with study material		O	
Device function score		O	
Collecting operation related outcomes		O	
Adverse event		O	O
Economic evaluation		O	O

M month, *W* week, *D* day

Recruitment {15}

The participant recruitment will take place at gynecologic clinics of eight university-affiliated hospitals, and these institutions, being part of KGOG with ample experience in conducting multicenter clinical trials, were chosen to ensure proficient recruitment of participants.

Assignment of interventions: allocation

Sequence generation {16a}

Patients will be allocated to cohort 1 or cohort 2 based on the comparator AHD. A centralized block randomization method is used, assigning patients in blocks of four, with two patients in each intervention arm within a cohort. An independent statistician who generates the randomization sequence retains access to it, while it remains concealed from trial staff.

Concealment mechanism {16b}

In each cohort, the allocation will be concealed until just before surgery, meaning that neither the participants nor the surgeons know which intervention arm the patient is assigned to beforehand.

Implementation {16c}

In each cohort, the randomization sequence will be generated by an independent statistician commissioned through a contact research organization, and the randomization number will be issued through a web-based randomization service provided by mytrial.co.kr.

Assignment of interventions: blinding

Who will be blinded {17a}

Participants will be blinded and unaware of which AHD will be used for their surgery. However, surgeons cannot be blinded due to the hands-on nature of the procedures.

Procedure for unblinding if needed {17b}

Since the operation room staff need to know the assigned AHD to prepare and use it during the procedure, surgeons will be informed about which AHD is assigned just before surgery.

Data collection and management

Plans for assessment and collection of outcomes {18a}

A research assistant will collect demographic information, perioperative outcomes, costs, and surgeons' evaluation scores. The assistant will be trained in using EDC systems and enter the data into the EDC system via the Internet. Follow-up data will be linked to the baseline database using enrollment numbers.

Plans to promote participant retention and complete follow-up {18b}

In order to increase patient participation, the follow-up process will be similar to that of a typical TLH at the study site. Participants will have a follow-up appointment 6 weeks after surgery, which is the usual recovery period following a hysterectomy. Except in cases where adverse events occur, participants will not need to make additional hospital visits for this study. The follow-up can be conducted either through an in-person visit or via phone.

Data management {19}

Data of participants will be collected using an EDC system. To ensure data quality, queries will be sent to researchers if any entered values fall outside predetermined ranges. Investigators must retain clinical trial-related documents, such as written consent forms and supporting documents, for a period of 3 years from the official end date of the clinical trial, in accordance with relevant regulations.

Confidentiality {27}

Records that can identify participants must be kept confidential, and investigators will document related information using an identification code for each participant. A list of participant identification codes must be maintained for cases where participant verification is necessary. Data analysis will be conducted only after all personal patient information has been anonymized. All collected data will be securely stored in encrypted databases (mytrial.co.kr) with restricted access, and only authorized personnel will have access to the information. The system will maintain audit trails to monitor data access and modifications, ensuring compliance with relevant data protection regulations, including KGCP (Korean Good Clinical Practice).

Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular analysis in this trial/future use {33}

There is no plan for genetic or molecular analysis.

Statistical methods

Statistical methods for primary and secondary outcomes {20a}

This trial is based on the full analysis set, including those who do not complete the protocol after randomization. Continuous variables are summarized as mean with standard deviation or median with interquartile range. Categorical variables are presented as numbers with percentages. The primary outcome, operative time, is analyzed using a *t*-test. The difference between the two groups is presented with a 95% confidence interval (CI). If the lower limit of the CI is lower than the pre-specified margin of 25 min, Vi-Sealer will be considered non-inferior to the comparator(s). Statistical significance for the non-inferiority test is set at 0.025. Secondary outcomes are analyzed using a *t*-test for continuous variables. For categorical variables, a chi-square test or Fisher's exact test is used to compare the proportions of each outcome. All statistical analyses are conducted using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA). All tests, except for the non-inferiority test, are two-sided with a significance level of 0.05.

Interim analyses {21b}

There are no interim analyses planned.

Methods for additional analyses (e.g., subgroup analyses) {20b}

Following the pooling of data from two randomized controlled trials, we will assess the differential impact of various hemostatic devices on surgical outcomes. In addition to patient-specific factors such as uterine size and age, we will also evaluate the potential influence of surgeon-related characteristics on perioperative results.

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

For efficacy evaluation variables such as operation duration, which are measured at a single time point, complete case analysis will be performed initially. If the extent of missing data is considered sufficient to compromise the planned statistical inference, multiple imputation will be employed to address the missingness. For other variables, the analysis will utilize the available data set without replacing any missing values.

Plans to give access to the full protocol, participant-level data and statistical code {31c}

Following the completion of the study, all data and statistical code will be formally transferred to the Korean Gynecologic Oncology Group (KGOG), the coordinating center. These materials will be accessible through a reasonable request directed to the corresponding author. Access is also contingent upon the agreement of the KGOG.

Oversight and monitoring

Composition of the coordinating center and trial steering committee {5d}

The current trial will be coordinated by KGOG, with dedicated research staff providing daily support. The trial coordination center will be responsible for data

management, including randomization schemes, data validation, and analysis, as well as ensuring study quality across institutions through meeting scheduling, feedback reception, and administrative tasks.

A trial steering committee, consisting of principal investigators and sub-principal investigators from each institute, as well as independent members (e.g., external clinical experts), will hold semi-annual meetings to oversee study progress, data collection, protocol modifications, statistical results, and report drafting.

Composition of the data monitoring committee, its role and reporting structure {21a}

An independent data safety monitoring board (DSMB), comprising gynecologists, an epidemiologist, and a statistician, will be established to monitor patient safety and adverse event development. Meetings will be scheduled within a month of enrolling the 10th and 70th patients and at trial completion. Oversight reports are submitted to the principal investigator (PI) or sponsor, as recommended.

Adverse event reporting and harms {22}

Adverse events will be collected up to 6 weeks post-operation and graded according to relevance and severity in accordance with the National Cancer Institute Common Terminology Criteria for Adverse Events (NCI CTCAE), version 5.0. Causality assessments will be performed by site investigators in consultation with the DSMB, which will determine whether adverse events are related to the trial intervention. Severe adverse events must be reported to the Institutional Review Board (IRB) by the PI immediately upon recognition, with treatment also documented in follow-up reports. All adverse events will be recorded in the EDC system as variables for evaluating safety and cost.

Frequency and plans for auditing trial conduct {23}

A designated KGOG staff member will audit the trial conduct, including consent form acquisition, adherence to eligibility criteria and randomization processes, and data completeness, monitored every 6 months.

Plans for communicating important protocol amendments to relevant parties (e.g., trial participants, ethical committees) {25}

All amendments to the study protocol will be documented and communicated to both the researchers and the IRB. If both the researchers and the IRB determine that the amendments are significant and warrant notifying participants, then the participants will be informed about the changes, and the consent will be sought regarding the amended protocol prior to continuing with the trial.

Dissemination plans {31a}

The results of this study will be presented at international conferences or published in academic journals. The findings will be shared with participants upon request. A plain-language summary of the trial outcomes will be made available after study completion, either through direct communication (e.g., email or printed summary) or via the website of the coordinating center, KGOG.

Discussion

Vi-TLH (KGOG4009) is an open-label, randomized controlled, non-inferiority trial comparing a new device, Vi-Sealer, with currently available AHDs. This study will assess the efficacy and safety of Vi-Sealer in patients undergoing TLH for benign gynecologic diseases. Additionally, the cost analysis of Vi-Sealer will be analyzed, as this reusable device is expected to impact medical costs.

AHDs can seal tissue and vascular bundles and enable consecutive transection. The computer algorithms in AHD generators monitor tissue conditions, such as impedance and temperature, and provide feedback through automatic shut-off or audible signals. This allows for precise energy delivery and reduced lateral thermal spread, improving thermal management. After sealing, the desiccated tissue can be cut with a mechanical blade or an ultrasonic transducer within the jaws without changing instruments. Consequently, these multifunctional devices are considered safe and time-efficient [16].

These new devices appear efficient due to reduced intraoperative blood loss and shorter operative times across multiple surgical specialties. As AHDs become widely adopted, economic and ecological concerns arise because most available AHDs are single-use. Therefore, a reusable type comparable in efficiency and operative outcomes is needed. Some institutions have initiated movements toward zero-carbon goals to reduce hospital waste [17]. A few reusable devices have been introduced, claiming advanced features and easy disassembly for cleaning and disinfection [18].

Despite the appeal and safety of AHDs, there is a lack of high-quality trials to guide clinicians in using these modalities in laparoscopic surgery to improve perioperative outcomes. To our knowledge, the current trial is one of the largest studies conducted to provide solid evidence for AHDs in vessel sealing systems. The trial design includes testing the reusable Vi-Sealer against

LigaSure and other AHDs. Patients are stratified into two cohorts based on the comparator. In cohort 1, a head-to-head comparison is performed between Vi-Sealer and LigaSure. Market research shows that LigaSure dominates about 60% of AHD purchases, making it an ideal candidate for this study (https://www.grandviewresearch.com/industry-analysis/vessel-sealing-devices-market-report#). In cohort 2, various AHDs with different energy sources can be selected for the control group at the surgeons' discretion. So far, no single vessel-sealing technique has proven superior. We hope that Vi-Sealer, tested against multiple AHDs currently used in real-world settings, will provide a basis for further studies evaluating AHDs.

Reusable devices cost less per use, but single-use devices may reduce overall surgical costs if they can safely decrease operative time. The cost analysis of reusable devices is debatable and involves a complex calculation considering various healthcare system conditions. The net effect of new devices can be seen as the overall cost change in the target surgery by replacing previous devices or the summation of cost increases from the new device and cost savings from its use. This can be calculated from three categories: the cost of the single-use device, the cost per case of the reusable device, and the cost per minute of operating room time [19]. Although adverse events are rare, the cost of additional procedures and admissions must be considered if they occur. This study will collect all bills issued for the target disease and surgery during the study period. The economic burden from these categories will be comprehensively analyzed to measure the cost-effectiveness of Vi-Sealer.

Surgeons' subjective evaluations are included in this trial. The choice of surgical routes or devices in hysterectomy, influenced by multiple factors, aims to improve patient outcomes and satisfaction. Surgeons' preferences are considered as they are assumed to correlate with surgical outcomes or adverse events, even though their incidence is low for evaluation in trials. For example, robot-assisted hysterectomy is debated for its high cost but is widely accepted for benefits like improved ergonomics, resulting in surgeon satisfaction [20]. Currently, no validated questionnaire exists for this trial. Eight categories representing the multifaceted abilities of AHDs as forceps, energy devices, or cutters will be graded.

AHDs have reduced operation time and blood loss in laparoscopic surgery. Most AHDs are single-use, increasing the economic and ecological burden on the healthcare system. The reusable type with advanced features has the potential to be non-inferior to single-use AHDs in terms of blood loss during TLH. This trial will examine the efficacy of Vi-Sealer in terms of clinical outcomes, cost analysis, and surgeons' satisfaction.

Trial status

The KGOG4009_Vi-TLH study protocol version is 1. The study commenced patient recruitment in November 2022 and is currently open for enrollment. The study is planned for completion within 36 months of initiation.

Abbreviations

AHD	Advanced hemostatic device
TLH	Total laparoscopic hysterectomy
RCT	Randomized controlled trial
EDC	Electric data capture
CI	Confidence interval
KGOG	Korean Gynecologic Oncology Group
PI	Principal investigator
IRB	Institutional Review Board

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13063-025-09222-w.

Supplementary Material 1.

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Authors' contributions {31b}

HP is the chief investigator; he conceived the study and led the proposal and protocol development. MK wrote and edited the manuscript. HP, KK, SJS, and SWK contributed to study design and to the development of the proposal. HP, WYK, STP, and YJC were the lead trial methodologists. All authors read and approved the final manuscript.

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Data availability {29}

The dataset will be available from the corresponding author. The KGOG will evaluate the reasonability of data sharing upon request.

Declarations

Ethics approval and consent to participate {24}

This study was approved by the CHA University Institutional Review Board (IRB No. 2022-09-044-016). Written informed consent will be obtained from all participants.

Consent for publication {32}

This manuscript does not include any baseline or pilot data from participants. A model consent form and other related documentation given to participants and authorized surrogates will be provided on request.

Competing interests {28}

The authors declare that they have no competing interests.

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