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Midline incisional hernia prophylaxis using synthetic mesh in an emergency or urgent gastrointestinal tract surgery: a protocol for multicentre randomised clinical trial

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ABSTRACT

Introduction Between 5% and 30% of abdominal incisions eventually result in incisional hernias (IHs) that can lead to severe complications and impaired quality of life. Unfortunately, IH repair is often unsuccessful; therefore, hernia prophylaxis is an important issue. The efficacy of mesh augmentation has been proven for hernia prophylaxis in high-risk patients, but no randomised clinical trial has evaluated prophylactic mesh placement in emergency/urgent gastrointestinal operations.

Methods and analysis A multicentre, prospective randomised, open and patient-assessor blinded endpoint design will be conducted. A total of 470 patients will be enrolled and randomly allocated to retrorectus mesh augmentation with lightweight polypropylene mesh or primary suture closure. The primary outcome is IH occurrence within 24 months of follow-up, while other clinical outcomes are secondary endpoints. A cost-effectiveness analysis will be conducted from the societal and provider perspectives.

Ethics and dissemination Ethics approval was obtained from Ramathibodi Hospital (MURA2020/1478) and Vajira Hospital (COA164/2563). The protocol is on the process of submission to the local ethics committee of the other study sites. Results will be submitted for publication in a peer-reviewed journal.

Trial registration number TCTR20200924002.

INTRODUCTION

Incisonal hernia (IH) is a common complication following an abdominal operation. The incidence of IH varies between 5% and 20% in the general population, increasing to almost 30% in high-risk populations; those with midline laparotomy for gastrointestinal (GI) surgery are the most vulnerable to IH.1 Evidence from meta-analyses suggests that mesh-augmented fascia closure may reduce IH incidence in midline incision, with a risk reduction of 70%–86%.2,4-7 Furthermore, a network meta-analysis5 has indicated that mesh positioning in midline laparotomy also affects IH prophylaxis and that retrorectus mesh (RM) placement may be the most suitable option, considering both benefits and risks.

The incidence of IH ranges from 16% to 33% after emergency laparotomy.3-13 A large retrospective study, consisting of 29739 subjects, reported that IH incidence after an emergency operation was as high as 16%, compared with 2% following elective surgery.13 Nevertheless, prophylactic mesh efficacy in lowering hernia occurrence in emergency or urgency patients has never been evaluated in any randomised clinical trial (RCT). Evidence from observational studies10,11 comparing prophylactic mesh augmentation and conventional fascia closure in emergency abdominal operations highlights the benefits of mesh placement without significantly impacting complication rates. A recent meta-analysis14 to assess the effects of prophylactic mesh in emergency laparotomy has included only observational studies10,11.
identifying significantly lower IH compared with non-prophylactic mesh. However, this evidence is potentially biased, given data synthesis is based on observational studies. A recent RCT15 just published on submission of our protocol has demonstrated efficacy of mesh prophylaxis in lower fascial dehiscence, not IH occurrence, when compared with no-mesh in emergency laparotomy.

Given the lack of evidence, an RCT is necessary to assess the benefits and risks of mesh for hernia prevention in patients undergoing midline laparotomy under emergency/urgency GI conditions. The proposed RCT will compare RM, using non-absorbable (polypropylene) mesh, to primary suture closure (PSC) to evaluate the hypothesis that RM will lower IH incidence compared with PSC in this particular group of patients. The primary endpoint is IH, and other clinical outcomes will be considered.

**Study objectives**

**Primary objective**

This proposed study aimed to assess the IH prevention effect of the non-absorbable mesh when placed in the retrorectus plane compared with PSC.

**Secondary objectives**

- To assess the safety of mesh placement in terms of adverse events (e.g., surgical site infection (SSI), seroma, haematoma, etc).
- To compare abdominal wall closure time, length of hospital stay, and level of postoperative pain between RM and PSC.
- To perform a cost-effectiveness analysis of RM augmentation in IH prophylaxis indication.
- To report the overall mesh removal rate.

**METHODS AND ANALYSIS**

**Study design and setting**

This study is a multicentre, prospective randomised, open, patient–assessor blinded endpoint trial, which will potentially include six centres: Ramathibodi, Vajira, Bhumibol Adulyadej, Hatyai, Maharat Nakhon Ratchasima and Surin hospitals. Protocol development follows the Standard Protocol Items: Recommendations for Interventional Trials guideline.16 This trial was registered at Thai Clinical Trials Registry.

**Patient and public involvement**

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our study.

**Inclusion criteria**

- Adults aged 18 years.
- Have undergone any type of GI surgery within 24 hours after admission or consultation with suspected GI pathology.
- Have received midline abdominal incision with an incision length of at least one-fourth of the distance from the xiphoid process to the pubic symphysis.

**Exclusion criteria**

- Potential second-look operation or planned revisionary surgery via a midline incision.
- Secondary fascial closure.
- Existence of midline IH and/or history of midline IH repair.
- Pregnancy or plan for pregnancy after surgery.
- Connective tissue disorders.
- Current or planned immunosuppressive use.
- Allergy to polypropylene.

**Intervention**

At the end of the index procedure, decontamination of the abdominal cavity will be performed with at least 3 L of normal saline. Participants will be allocated to either RM or PSC (figures 1 and 2) prior to abdominal wall closure. Intervention details will be as follows.

**Primary suture closure**

Single-layer closure of the linea alba will be performed for all collaborative sites using a 1–0 polydioxanone suture (PDS). Small tissue bite (i.e., 5–8 mm bite) and small (5 mm) intersuture spacing with continuous suturing will be applied to ensure a wound to suture length ratio of 1:4; this will be recorded in a case record form. No retention suture will be applied. Additional decontamination with at least 1 L of normal saline will be performed.

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**Figure 1** Retrorectus mesh augmentation.

- Have an American Society of Anesthesiologist physical status class of 1–4.

**Figure 2** Primary suture closure.
at the subcutaneous layer. Surgeons will decide whether skin and subcutaneous tissue will be closed or left open for wet dressing. In the event of skin and subcutaneous tissue closure, the subcutaneous space should be obliterated using multiple stitches of absorbable suture without a subcutaneous drain in place. Skin can be approximated using non-absorbable suture or staples.

**RM augmentation**

A plane between the rectus muscle and the posterior rectus fascia/peritoneum will be developed to achieve a 3 cm distance from the fascial edge in all directions. The posterior rectus fascia/peritoneum closure will be performed using a continuous suture with a 1–0 PDS. A piece of 6×15 cm lightweight macroporous polypropylene mesh (weight 38 g/m² and 1.5 mm pore size) will be placed anterior to the posterior rectus fascia/peritoneum. Overlapping of the mesh and the fascia incision should be 3 cm in all directions. A second mesh piece can be used as necessary, with 2 cm overlapping with the first mesh piece. Mesh will be fixed to the posterior rectus fascia at its four corners and the mid-length using 3–0 polypropylene sutures. No drain will be placed in the retrorectus space. Closure of the anterior rectus fascia will be performed as described in the PSC group. Skin and subcutaneous tissue will be managed as described previously.

**Training**

Participating surgeons and surgical residents will be trained by principal investigators to achieve consistent standards for RM and PSC techniques. A tutorial video of RM and PSC is available for each study centre. For RCT enrolment, RM must have been performed on at least five occasions for each study site.

**Cointerventions**

Empirical antibiotics will be given according to suspected pathogens and allergic status for each participant. After culture and susceptibility results are available, the type of antibiotics and its course will be adjusted accordingly. Medications will be administered intravenously and switched to oral form after being afebrile for 24–48 hours. Participants will receive 0.5 mg/kg of pethidine or 0.05 mg/kg of morphine intravenously every 4 hours as a standard pain control with additional opioid doses for breakthrough pain. This pain control is initially for the first 24 hours and will be adjusted on subsequent days, depending on the participant’s pain level. Other options for pain relief will include patient-controlled analgesia or epidural anaesthesia. After oral intake is resumed, oral acetaminophen or non-steroidal anti-inflammatory drugs will be prescribed.

An oral diet will be ordered when GI function is detected. Breathing exercises and rehabilitation will be encouraged as per usual practice. No abdominal binders will be applied.

**Outcomes and measurement**

**Primary endpoint**

IH occurrence is the primary outcome of interest and will be measured at 3, 6, 12, 18 and 24 months after index operation. A telephone call will be made by research assistants to remind participants of follow-up. The diagnosis will be made by physical examination. Dynamic ultrasound will be used as a supplement in equivocal cases (ie, participants who complain of lump or discomfort at a surgical incision without a definite physical sign of hernia). CT will only be considered where ultrasound results are uncertain.

**Secondary endpoints**

Table 1 shows the outcome measurements according to each follow-up visit. Secondary outcomes are listed as follows:

- **SSI** is defined according to the Centers for Disease Control and Prevention diagnostic criteria (see box 1). Both superficial and deep SSIs will be included. Because the intervention involves a foreign body placement, follow-up will be scheduled for 1 year to detect a deep SSI. Once there is SSI occurrence, treatment managements will be recorded including

| Table 1 | Timetable for clinical outcome measurements |
|---------|---------------------------------------------|
| **Outcome** | **Days 1 and 3** | **Within 1 month** | **3 months** | **6 months** | **12 months** | **18 months** | **24 months** |
| Incisional hernia | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Surgical site infection | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Seroma | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Burst abdomen | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Haematoma | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Enterocutaneous fistula and wound sinus | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Acute pain | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Chronic pain | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
antibiotic uses, open or percutaneous drain, and negative pressure wound therapy, and timing of SSI treatment.

- **Burst abdomen** is defined as a fascial wound defect combined with internal organ evisceration, which occurs within 30 days after the index operation causing mandatory repair of the fascial wound.
- **Seroma** is defined as fluid collection in the area of incision or serous leakage through the wound, which appears within 3 months after the index operation.
- **Haematoma** is defined as a collection of blood, appearing in the incision within 7 days after the index operation, for which evacuation is needed.
- **Enterocutaneous fistula** and **chronic wound sinus**, which are rare complications, will be observed for 12 months.
- **Acute postoperative pain** will be recorded on days 1 and 3 after surgery. The pain score will be measured in the range from 0 (no pain) to 10 (worst pain).
- **Chronic pain** is defined as pain in any degree persisting at the incisional scar. This outcome will be evaluated at 3, 6, 12, 18 and 24 months after surgery.
- **Length of hospital stay** will be recorded as the number of days spent on admission after the index operation.

**Box 1  Superficial and deep SSI according to the criteria of the Centers for Disease Control and Prevention**

**Superficial SSI**
Infection occurs within 30 days after the operation and infection involves only skin or subcutaneous tissue of the incision and at least one of the following:
- Purulent drainage, with or without laboratory confirmation, from the superficial incision.
- Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
- At least one of the following signs or symptoms of infection: pain or tenderness, localised swelling, redness or heat, and superficial incision is deliberately opened by surgeon, unless incision is culture-negative.
- Diagnosis of superficial incisional SSI by the surgeon or attending physician.

**Deep SSI**
Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place, and the infection appears to be related to the operation and infection involves deep soft tissues (eg, fascial and muscle layers) of the incision and at least one of the following:
- Purulent drainage from the deep incision but not from the organ/ space component of the surgical site.
- A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localised pain or tenderness, unless the site is culture-negative.
- An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation or by histopathological or radiological examination.
- Diagnosis of a deep incisional SSI by a surgeon or an attending physician.

SSI, surgical site infection.

**Consent**
Eligible patients will be invited to participate at the time when consent to operate is obtained and will be provided with information about the trial’s objective, benefits, and risks of interventions (see online supplemental document 1). Patients will be informed that their decision will not influence treatment, and the right to withdraw from participation at any time is preserved. All patients will be provided with at least 15 min to make a decision. Informed consent will be obtained by the principal investigators or authorised research assistants and signed by the participant and the witness before randomisation.

**Randomisation and concealment**
Participants will be randomly allocated to either RM or PSC, with a ratio of 1:1, by the research assistant. Stratified block randomisation will be used to generate random sequence lists considering collaborating centres as strata, with varying block sizes of 4–8. The allocation sequence will be confidential and kept in the Central Data Management Unit at the Department of Clinical Epidemiology and Biostatistics, Ramathibodi Hospital. Sequential numbers will be concealed in envelopes and distributed to each centre. Randomisation and concealment will be undertaken by statisticians not participating in the trial. Allocated treatment will be revealed to the surgeon prior to abdominal wall closure.

**Blinding**
Patients and outcome assessors will be blinded to avoid bias in outcome assessment. Although surgeons who perform the operations cannot be blinded, they will not be involved in outcome assessment. Intervention instructions will be available to the surgical team and patients under emergency situations or as a result of complications where knowledge of the treatment allocation is necessary.

**Data management**
Research assistants will record anonymised data in CRF, which will be checked for accuracy by the principal investigators. Any uncertainty will be resolved by cross-checking primary data sources. The principal investigator (ATa) will check and approve all CRFs before data entry. Web or onsite databases will be constructed following the structure of CRFs. A data quality control program will be undertaken by statisticians not participating in the trial. Allocated treatment will be revealed to the surgeon prior to abdominal wall closure.
Sample size determination
A meta-analysis was applied to pool five RCTs of RM versus PSC,18–22 which demonstrated approximately 70% lower IH risk by RM. As such, we estimate a risk reduction of at least 50% should be clinically relevant. Postoperative emergency surgery incidence of IH from five studies9–13 ranged between 16% and 33%, compared with 7% at Ramathibodi Hospital in 2019. A pooled IH incidence of 19% was estimated from previous studies and Ramathibodi Hospital. Type I error and the power of the test will be 0.05 and 0.8, respectively. Using a randomisation ratio of 1:1, a sample size of 424 subjects is estimated. Considering a potential loss to follow-up of 10%, 470 participants will be recruited over an enrolment period of 18–24 months (figure 3).

Statistical analysis
Categorical variables will be described by frequency and percentage, whereas continuous variables will be reported as mean and SD or median and range where appropriate. The balance of covariables between the two intervention groups will be explored and compared using \( \chi^2 \)/Fisher’s exact and independent Student’s t-test/quantile-regression for categorical and continuous variables, respectively.

The incidence of IH, along with 95% CIs, will be estimated separately by the intervention groups; a relative treatment effect will be then assessed by estimate RR and risk difference (RD). In addition, the number needed to treat, along with the 95% CI, will be estimated accordingly. In case that randomisation could not work well (or in other words, covariables are unbalanced between the intervention and control groups), these RRs and RDs will be estimated using a bivariate regression analysis with adjustment for covariables.

Protocol violation
Protocol violation may result from mistaken treatment delivery, or surgeons may deliver another intervention, not the assigned intervention to the subject. Protocol violations will be considered using three approaches: intention to treat (ITT), per protocol (PP) and as treated (AS). These analyses will be applied for all major outcomes (ie, IH and SSI), but only ITT will be used for the secondary outcomes.

The ITT analyses patients in the groups to which they are randomised, regardless of actual treatment. The PP analysis will consider only patients who adhere to their allocated intervention and excludes those patients who do not receive their allocated intervention after randomisation. The AS analysis will consider the actual received intervention, regardless of randomisation, with adjustment of covariables at baseline using a counterfactual approach by an instrumental variable (IV) regression.23 24 For this, the assigned intervention will be considered as the IV, while the actual received intervention will be an endogenous variable. Two-stage bivariate probit or a logistic model, where appropriate, will be applied to estimate the effect of the intervention with adjustment for covariables.

Imputation
We will manually search for missing data in case record forms and medical records. If such data cannot be retrieved, missing data will be assumed to be missing at random, and imputation will be performed. The missing data will be regressed on complete data using linear truncated/interval or logistic regression with 10 imputations, depending on the variable type. The fraction of missing information and relative variance increase will be calculated as indices to assess imputation performance.

Cost-effectiveness analysis
Analyses will be based on societal and provider perspectives. The time horizon will be 24 months. Therefore, discounting will be applied to all costs. IH RD (\( \Delta \)effectiveness) and cost difference (\( \Delta \)cost) between SM and PSC will be calculated. The incremental cost-effectiveness ratio (ICER) will be computed by dividing \( \Delta \)cost by \( \Delta \)effectiveness.

\[
\text{ICER} = \frac{\Delta \text{cost}}{\Delta \text{effectiveness}}.
\]

ICER and its replications from 1000 Monte Carlo simulations will be plotted on a cost-effectiveness plane according to different willingness-to-pay thresholds. The cost-effectiveness acceptability curve will be constructed as a function of willingness-to-pay thresholds. The net
monetary benefit (NMB) will be computed at each threshold based on the following equation:

\[ \text{NMB} = R \times \text{Effectiveness} - \text{Cost} \]

where R is the willingness-to-pay threshold.

One-way sensitivity analyses will be performed where appropriate. Results from a series of one-way sensitivity analyses will be presented in a tornado diagram.

**Interim analysis**

Two additional analyses will be undertaken by an independent statistician, blinded to treatment allocation, before enrolment is completed. These analyses will evaluate the safety of the mesh placement and influence on short-term SSI rate when 50%, and 75% of participants have enrolled or overall deep SSI is 5% or higher; this will be undertaken by the data safety and monitoring board (DSMB). To avoid inflation of type I error, the alpha-spending function, proposed by O’Brien and Fleming, will be used for p value adjustment. After all participants have been enrolled, analyses for all interest outcomes will be completed.

**Analysis for early data release**

Early data release would provide useful information to the science community. Thus, additional analysis will be conducted after complete enrolment and 12-month follow-up in all participants. Secondary outcomes, including SSI, seroma, haematoma, chronic pain and fistula, will be analysed and reported. Multiple-comparison adjustment is not required for this analysis because data will not affect the release and follow-up protocol. After all participants are enrolled and followed up for 24 months (ie, the planned follow-up period for IH occurrence), the analyses defined will be repeated, and the trial will be concluded.

**Monitoring and safety**

The proposed DSMB will consist of surgeons, epidemiologists and biostatisticians independent of the RCT. DSMB meetings will be organised every 6 months and when thresholds are reached. All adverse events (eg, SSI, seroma, haematoma, etc) and relevant source documents for data validation will be reported and accessible to DSMB in a confidential manner.

**Early termination of the trial**

In consultation with the steering committee and the DSMB, the investigators may terminate the trial at the recommendation of the DSMB for a number of possible scenarios:

- High rate of serious complications, for example, significantly higher SSI rate in the intervention group.
- Rate of enrolment was poor.
- External independent evidence that suggested the trial was unethical or where new research evidence is released.

**ETHICS AND DISSEMINATION**

This study will be conducted following the Declaration of Helsinki and the International Conference on Harmonisation—Good Clinical Practice E6 recommendation. The enrolment in each study site will commence after the approval of the local ethics committee. The study has been approved by the ethics committee of Ramathibodi Hospital, which is the main institute (MURA2020/1478), and also the collaboration cite including Vajira Hospital (COA164/2563). Written informed consent must be obtained before participation. Adverse events will be treated according to the standard of care and reimbursed according to Thai healthcare reimbursement schemes. No biological specimens will be collected as part of this trial.

Results of this trial will be published in a peer-reviewed journal. Only summary data, which cannot identify individual participants, will be presented in manuscripts. Datasets will be anonymised and made available for sharing among researchers.

**DISCUSSION**

An IH incidence of 20% following abdominal surgery commonly results in complications and poorer quality of life, necessitating hernia repair. Unfortunately, the recurrence rate is high, regardless of the repair technique (7.3%–21.1%), emphasising the importance of hernia prophylaxis. A cost analysis of IH repair in France concluded that 4 million euros could be saved per year by reducing IH incidence by 5%. A significant body of evidence exists demonstrating the efficacy of mesh augmentation in hernia prophylaxis, especially in high-risk patients. Emergency operation is another risk factor for IH; however, none of the published RCTs investigated the efficacy of prophylactic mesh placement specifically in this group of patients. This RCT aims to examine the effect of RM augmentation on IH occurrence after emergency/urgent midline laparotomy.

Even though RM may be less effective than onlay mesh for hernia prevention, it results in less wound-related complications. Thus, RM augmentation was selected as the intervention of interest. The Preemer trial is currently assessing the efficacy of RM placement in emergency laparotomy, although the technique used differs from that proposed here. The Preemer trial uses a self-grasping mesh instead of the commonly used polypropylene mesh. Considering costs, the plain lightweight polypropylene mesh might be more easily adopted for prophylaxis.

The proposed trial has several strengths. The sample size is relatively large compared with previous studies of IH prophylaxis. Moreover, participants, outcome assessors and data analysts will be blinded to minimise potential bias. Furthermore, the primary outcome will be assessed at 24 months, in line with the European Hernia Society guidelines, and all related costs will be evaluated alongside clinical outcomes providing measures of cost-effectiveness to inform policy decisions.
This trial will have some challenges. The intervention requires significant surgical expertise, although this is ameliorated by technique standardisation and appropriate training procedures. Protocol violations may occur but will be considered under ITT, PP and AS. In addition, intervention adherence will be evaluated using IV regression analysis, which maintains the benefits of the randomisation process.

In conclusion, this trial is a prospective, randomised, open, blinded endpoint design that will inform hernia prevention, especially in emergency/urgency settings.

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Contributors Ata is the principal investigator. Ata, ST and PS designed the study. ATh provided help in statistical design. ATh drafted the manuscript. ATh, PN, GMK and JA critically revised the study design and the manuscript. The entire project will be supervised by PN, PS and ATh.

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CONSENT BY SUBJECT FOR PARTICIPATION IN A RESEARCH PROTOCOL

STUDY TITLE: Midline incisional hernia prophylaxis using synthetic mesh in an emergency or urgent gastrointestinal tract surgery: A multicenter randomized clinical trial

INVESTIGATORS: Amarit Tansawet, Pawin Numthavaj, Preeda Sumritpradit, Suphakarn Techapongsatorn, Ammarin Thakkinstian

Name of participant ................................................................. Age......................

Consent by participant

I, _______________________________ (Participant’s name), have been clearly informed of the details of the research project, including benefits and risks of the participation. I am aware that I can contact the study investigators if questions or concerns arise. The participation is voluntary and I do not have to sign this form if I do not want to be involved in the study. The personal information collected will be kept confidential and will only be use for research publications or presentations. My name and other identifying information will be removed before this data is used. Identifying information may be reviewed by the institution in case of academic necessity only.

______________________________
Signature of participant

______________________________
Witness

______________________________
Date

Consenting Investigator

I have explained and disclosed the nature and purpose of the study and the risks involved to the parent/guardian of the participant, with no undisclosed information.

______________________________
Signature of Investigator

______________________________
Date