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## Research Paper

## Impact of the COVID-19 pandemic on the outcome, morbidity, and mortality of acute care surgery patients: A retrospective cohort study

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## ABSTRACT

**Background:** Coronavirus disease (COVID-19) has impacted both emergency and elective surgical management owing to its highly infectious nature and the shortage of personal protective equipment. This study aimed to review the outcomes of emergency surgical conditions and trauma during the pandemic lockdown.

**Material and methods:** We retrospectively reviewed and collected data from patients who attended the Acute Care Surgery Service from 1st April to May 31st, 2020 during Thailand's COVID-19 pandemic lockdown. We separated staff and performed preoperative COVID-19 swab testing on all patients to assess the requirement for personal protective equipment. Compared with previous years of service, of 2018 and 2019. Preoperative COVID-19 testing was performed using multiplex and manual RT-PCR. Morbidity and mortality, consultation time, and waiting time to surgery were analyzed.

**Results:** A total of 61 patients were enrolled. The average age of patients was 53.8 years. The average consultation time, waiting time to surgery, and surgical duration were 10 min, 660 min, and 88.77 min, respectively. The average time taken to obtain the preoperative COVID-19 test result was 227.26 min. The morbidity and mortality rates were 9.84% and 1.64%, respectively. Compared with the same period in 2018 and 2019, consultation time was significantly faster (10 min;  $p = 0.033$ ) and waiting time to surgery was significantly longer (660 min, respectively;  $p = 0.011$ ). Morbidity and mortality between pandemic period and the previous year of service were not significantly different. No medical workers were infected with COVID-19.

**Conclusions:** During the COVID-19 pandemic, optimal triage of emergency patients is key. Waiting for preoperative COVID-19 swab testing in emergency case is safe and results in good outcomes. Although the waiting time to surgery was significantly longer owing to the time required to receive preoperative COVID-19 swab results, morbidity and mortality rates were unaffected.

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## 1. Background

The coronavirus disease (COVID-19) outbreak placed a large burden on the global medical system. COVID-19 has affected Thailand, with Bangkok being the most affected province. Surgery has been reported in asymptomatic patients with COVID-19 [1,2].

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Since COVID-19 was declared a pandemic in over 160 countries by the World Health Organization, emergency, urgency, and elective surgery have been affected [3]. The infectious nature of severe acute respiratory syndrome coronavirus 2 (i.e., SARS-CoV-2) made this outbreak severe and difficult to control [4]. Hospital resources should be conserved for patients with COVID-19, such as hospital beds, intensive care unit (ICU) beds, ventilators, transfusion materials, and even personal protective equipment (PPE) [5]. Thus, the surgical schedule for non-emergency cases has been delayed during this pandemic. Shortage of PPE, such as surgical masks, respirator masks, gowns, face shields, and gloves, has changed the

way diseases are managed surgically [5]. It is important to arrange medical workers into teams to minimize face-to-face contact and limit viral spread. Anesthesiologists are on standby for COVID-19 emergency intubation and ICU support. Separation of staff and a shortage of anesthesiologists made our elective surgical theaters fall to 50% of normal service. In patients requiring elective surgery, we only performed surgery in cases of malignancy. In these patients, delayed surgery leads to an increased risk of mortality and morbidity, such as colorectal cancer, breast cancer, hepatopancreatobiliary tract cancer, urologic cancer, and neurologic cancer. Preoperative COVID-19 nasopharyngeal swab testing should be performed for all patients, and if patients test negative, surgery can go ahead. If patients test positive, surgery should be delayed and COVID-19 should be treated as a first priority. For patients requiring emergency or urgent surgery, the goal is to provide timely surgical management, even in those with suspected or confirmed COVID-19, while optimization of care resources and prevention of infection is paramount for medical workers. Non-surgical management is preferred providing it is feasible and safe [6,7]. Self-prevention measures taken by medical workers and organization of resource are mandatory. At the university hospital, we arranged for medical students to stay home and learn via an online platform during the lockdown period to minimize the spread of COVID-19 between medical workers and students.

The present article aimed to report the impact of the COVID-19 pandemic lockdown on the management and outcomes of patients with emergency or urgent surgical conditions and trauma from the Acute Care Surgery service.

## 2. Material and Methods

### 2.1. Patients

We retrospectively reviewed and collected data from patients who attended the Acute Care Surgery service from 1st April to May 31, 2020 during COVID-19 pandemic lockdown. The same period in 2018 and 2019 had no cases of COVID-19. Demographic data included age, gender, length of hospital stay, number of patients under investigation (PUI), number of patients and medical workers infected with COVID-19, consultation time, time to report preoperative COVID-19 swab results, time to surgery, surgical duration, management of emergency conditions, and morbidity and mortality rates. The ethics committee were approved the study. Our work has been reported with the STROCSS criteria [7].

### 2.2. Definitions

Consultation time was defined as the time of patient arrival at the emergency department to the time that general surgery residents visited patients. Time to surgery was defined as the time from patient arrival at the emergency department to the start of surgery. The time to report preoperative COVID-19 swab results was the time from specimen arrival at the laboratory to reporting of the results. Surgical duration was defined as the duration between the surgeon making an incision and the end of surgery.

Enhanced PPE comprised a medical cap, goggles or eye visors, a face shield, an N95 mask or a respirator mask, a medical gown, two pairs of disposable gloves, and shoe covers. Full PPE comprised a hair net, goggles or eye visors, a face shield, an N95 mask, an isolation gown, disposable gloves, and shoe covers. Standard PPE comprised a hair net, goggles or eye visors, a surgical mask, an isolation gown, disposable gloves, and shoe covers.

### 2.3. Pandemic lockdown workflow

#### 2.3.1. Management of emergency and urgent surgical conditions and trauma

Elective surgery was postponed with the exception of surgery for malignant conditions, such as colorectal cancer and breast cancer. Management of patients with emergency and urgent surgical conditions followed COVID-19 guidelines for triage set out by the American College of Surgeons, which encourage non-surgical management if feasible and safe for patients with suspected or confirmed COVID-19. Surgery is prompt when non-surgical management fails. If surgery is mandatory, such as surgery for hollow viscus organ perforation or bowel ischemia, PPE should be used to minimize viral exposure. Thus, triage and hemodynamics status should be managed while optimizing care resources [6,8]. For trauma, the management approach is determined on a case-by-case basis. Patients with unstable hemodynamics and life-threatening conditions are required to undergo emergency surgery.

#### 2.3.2. Trauma and acute care surgery staff and residents

The medical team were split into two and were only permitted to communicate by phone to avoid personal contact. Each team comprised two members of staff and four residents from years 1–4. In case a member of the team was infected with COVID-19 or had made contact with a patient who had tested positive for COVID-19, the team were required to isolate for 14 days, and services were maintained by another team to avoid disturbance to services.

#### 2.3.3. Strategies to maintain safety and minimize the risk of viral exposure to medical workers

During the lockdown period, our hospital attempted to conserve medical supplies and resources; thus, we had no refer-in cases during this 2-month period and encouraged a refer-out approach to hospitals near patients' places of residence.

We performed preoperative COVID-19 swab testing on every patient requiring emergency or urgent surgery, and also in trauma patients requiring surgery. For patients with unstable hemodynamics, surgery proceeded before obtaining preoperative COVID-19 swab test results, but full PPE was mandatory for all medical workers coming into contact with these patients. SARS-CoV-2 nasopharyngeal swab tests were processed by multiplex and manual real-time polymerase chain reaction with a guaranteed test report time of 3–6 h. A diagram of preoperative COVID-19 swab testing on patients requiring emergency surgery and use of PPE are shown in Fig. 1. In patients with confirmed COVID-19, anesthesiologists and surgeons who operate in the airway, thoracic cavity, and gastrointestinal tract were required to wear enhanced PPE [7]. Surgeons performing non-thoracic surgery were required to wear full PPE. When transferring patients, residents and nurses were required to wear standard PPE. Emergency surgery was performed within 1 h, including for life-threatening conditions such as bowel ischemia, septic shock, and trauma with profound shock. In such cases, the same type of PPE was used as for confirmed cases of COVID-19. Preoperative COVID-19 swab testing was performed, but surgery proceeded without waiting for the results. An urgency cases need to operate within 12 h, such as complicated appendicitis without septic shock or colonic obstruction without perforation, preoperative COVID-19 swab testing was performed and the results were received before surgery (Fig. 1). In case of a positive result, all medical workers were required to wear the enhanced PPE as staff coming into contact with confirmed cases of COVID-19. If negative, surgery with full PPE was deemed adequate to prevent infection [7].

Emergency cases	Operation room (OR)		Operation room and Post-anesthesia case unit (PACU)	Ward (negative pressure room)	
Confirmed case COVID-19	Enhanced PPE for Anesthesiologist, surgeon who operate in respiratory tract (chest, tracheosotmy, upper GI endoscopy), Nurse			Standard PPE for transfer, ward staffs, nurse	
	Full PPE surgeon for non-aerosal generating procedure				
Emergency case need operation within 1 hour	Swab in OR			Check Swab COVID-19 result move to ward by result	
	Enhanced PPE for Anesthesiologist, surgeon who operate in respiratory tract (chest, tracheosotmy, upper GI endoscopy), Nurse			Standard PPE for transfer, ward staffs, nurse	
	Full PPE surgeon for non-aerosal generating procedure				
Emergency case need operation within 24 hours	Admit in separate room Swab COVID-19 testing and waiting the result before operation	COVID-19 +			Standard PPE for transfer, ward staffs, nurse
			Full PPE surgeon for non-aerosal generating procedure		
		COVID-19 -	Standard PPE for surgery, transfer, ward staffs, nurse		

**Fig. 1.** The workflow of emergency and urgency surgical conditions of Acute Care Surgery service during COVID-19 pandemic lockdown period.

#### 2.3.4. Preparation of theater, dressing, and undressing

The number of surgeons, assistants, and scrub nurses in the operating theater was limited, as this area is at a high risk of infection. We attempted to reduce the surgical duration, so the most senior surgeons performed surgery with the assistance of one or two residents and one scrub nurse. Surgical equipment, such as aesthetic monitors, computers, and equipment containers, was covered by plastic wrap to facilitate cleaning. The operating theater door was closed at all times and opening of this door was limited during surgery to prevent the spread of infection. Staff, residents, nurses, and anesthesiologists involved in surgery were not permitted to leave the room until surgery had been concluded. Any unnecessary equipment was removed and equipment required for surgery was promptly prepared inside the room. The surgeon was required to use only equipment prepared in the room to minimize the number of times the theater door was opened after the patient had entered. Disposable equipment was favored because reusable equipment needs to be decontaminated, washed, dried, and sterilized immediately after surgery. Rapid sequence intubation was considered to avoid manual ventilation. Intubation while patients were awake was avoided where possible because it induces coughing. Patients were positioned and draped with a disposable sterile set for surgery. Smoke from electrocautery was suctioned immediately during surgery, even though there are no data to suggest viral spread of SARS-CoV-2 via bodily fluid [7]. After surgery, disposable equipment was discarded as hazardous waste, which was closed and sealed, immediately outside the operating theater. Patients were transferred to a ward or the ICU via the shortest fixed route that was separate from the route used by the public. The operating theater and surrounding area through which patients were transferred was sanitized as soon as possible.

Surgeons, residents, and scrub nurses were required to dress in PPE according to our workflow guidelines (Fig. 1) in a separate clean room near to the operating theater before meeting patients. Surgeons and assistants involved in surgery performed a hand scrub with Avagard™ after dressing in PPE. Staff were required to wear a disposable sterile suit inside the operating theater. If staff made any contact with infected patients or materials, they were required to change their gloves immediately. Particulate filtering face masks,

such as N95 masks, were worn during aerosol-generating procedures, such as airway, chest, and endoscopic surgery. After surgery, all medical workers were required to leave the operating theater and remove PPE with special care without touching external surfaces in the undressing area. Staff were then required to shower before leaving the operating room. Used PPE was disposed of in infectious and hazardous waste.

#### 2.4. Statistical analysis

Patient demographics and time data were analyzed and compared using a *t*-test, the Kruskal–Wallis test, the Wilcoxon signed-rank test, and the Chi-squared test. Stata 14.2 was used to analyze the data. A *p*-value of <0.05 was considered statistically significant.

This work has been reported in line with the STROCSS criteria [7].

### 3. Results

During Thailand's COVID-19 pandemic lockdown from 1st April to May 31, 2020, 61 patients requiring emergency surgery were enrolled. Thirteen patients had trauma emergencies and 48 patients had non-trauma emergencies or urgent general surgical conditions, shown in Table 1. The average age of patients was 53.8 years. The most common diagnosis of non-trauma patients was acute appendicitis in 17 cases (27.87%), which was managed by open appendectomy in 12 cases (70.6%) and non-surgical management in five cases (29.41%). Other diagnoses included lower gastrointestinal bleeding in five cases (8.2%), small bowel obstruction in five cases (8.2%), acute cholecystitis in three cases (4.91%), hollow viscus organ perforation in three cases (4.91%), upper gastrointestinal bleeding in three cases (4.91%), appendiceal abscess in two cases (3.28%), acute cholangitis in one case (1.64%), colonic obstruction in one case (1.64%), sigmoid volvulus in one case (1.64%), and other diagnoses, such as soft tissue infection, incarcerated inguinal hernia, and foreign body ingestion in seven cases (11.48%). The average length of hospital stay during lockdown was 4 days. The median consultation time was 10 min. The median

**Table 1**

The demographic data of emergency cases during Thailand's COVID-19 pandemic lockdown from April 1, 2020–May 31, 2020 of Acute Care Surgery service.

	Non-trauma N = 48	Trauma N = 13	Total N = 61
Sex			
Female	25 (52.08)	3 (23.08)	28 (45.90)
Male	23 (47.92)	10 (76.92)	33 (54.10)
Age (years): mean $\pm$ SD	55.57 (19.65)	47.38 (22.59)	53.8 (20.41)
LOS (days): median (iqr)	4 (4)	4.5 (6)	4 (5)
Person under investigation (PUI)	1 (2.17)	0	1 (1.69)
Consultation time (min): median (iqr)	10 (22)	5 (5)	10 (15)
Time to OR (min): mean $\pm$ SD	660 (480)	240 (630)	660 (472.5)
Time of COVID-19 testing result (min): mean $\pm$ SD	234.18 (112.37)	194.37 (121.22)	227.26 (113.58)
Operative time (hrs): mean $\pm$ SD	88.14 (52.13)	90.87 (55.04)	88.77 (51.99)
Management			
NOM without COVID-19 swab testing	9 (19.15)	1 (7.69)	10 (16.67)
Operation with pre-operative COVID-19 swab testing	23 (48.94)	5 (38.46)	28 (46.67)
Operation without pre-operative COVID-19 swab testing	2 (4.26)	3 (23.08)	5 (8.33)
Outpatient management	4 (8.51)	3 (23.08)	7 (11.67)
Endoscope with pre-operative COVID-19 swab testing	6 (12.77)	0	6 (10)
Percutaneous drainage with pre-operative COVID-19 swab testing	2 (4.26)	0	2 (3.33)
Percutaneous drainage with pre-operative COVID-19 swab testing	1 (2.13)	1 (7.69)	2 (3.33)
COVID-19 infected medical worker	0	0	0

time to surgery was 660 min, and the average surgical duration was 88.77 min. There were no PUI for COVID-19 infection. The median time to report preoperative COVID-19 swab test results was 227.26 min. No medical workers were infected with COVID-19 during the pandemic lockdown period. Management of emergency or urgent surgical conditions during the lockdown period is shown in Table 1. Non-surgical management without COVID-19 swab testing was performed in 10 cases (16.67%), and emergency surgery with pre-operative COVID-19 swab testing was performed in 28 cases (46.67%). Emergency surgery without waiting for the preoperative COVID-19 swab test report was performed in five cases (8.33%) due to life-threatening peritonitis with septic shock in two cases (4.26%), trauma with profound hemorrhagic shock (grade 4) in three cases (23.08%), penetrating trauma in the small bowel and colonic injury, and neurologic trauma impending brain herniation. For patients whose test results were not received before surgery, caution was taken by history assessment. This investigation did not reveal any PUI, so full PPE was adequate. Outpatient management was achieved in seven cases (11.67%). Endoscopic treatment with preoperative COVID-19 swab testing was performed in lower gastrointestinal bleeding (LGIB) in six cases (10%). Percutaneous drainage with preoperative COVID-19 swab testing was performed in two cases (3.33%) and without preoperative COVID-19 testing in two cases (3.33%). Morbidity and mortality rates were 9.84% and 1.64%, respectively.

A comparison with the same period in previous years is shown in Table 2. No statistically significant differences were found in morbidity (9.84% in 2020 vs. 6.5% in 2019 vs. 11.11% in 2018;  $p = 0.432$ ) and mortality (1.64% in 2020 vs. 0.81% in 2019 vs. 0% in 2018;  $p = 0.332$ ). The time to surgery was significantly longer compared with previous years of service (660 min in 2020 vs. 480 min in 2019 vs. 420 min in 2018;  $p = 0.011$ ). The consultation

time was significantly shorter during the lockdown period (10 min in 2020 vs. 12 min in 2019 vs. 15 min in 2018;  $p = 0.033$ ). The surgical duration was not significantly different (60 min in 2020 vs. 67.5 min in 2019 vs. 75 min in 2018;  $p = 0.219$ ). There were only one case came to hospital with obstructed rectal cancer because of delayed elective colonoscopy in COVID-19 lockdown period.

#### 4. Discussion

The COVID-19 pandemic has caused a great shortage of PPE. Hospitals need to conserve resources for patients with COVID-19, such as hospital beds, ICU beds, transfusion materials, ventilators, and PPE [9,10]. Anesthesiologists are required to be on standby to provide intensive care and prompt intubation to patients with suspected or confirmed COVID-19, thus a shortage of anesthesiologists is also a problem. At our hospital, because of the shortage of PPE, all patients with elective malignancies underwent surgery after preoperative COVID-19 swab testing. The goals of emergency surgery and surgery for trauma are timely surgical care and optimization of patient care resources. The American College of Surgeons published triage guidelines for managing acute surgical emergencies. For such cases, non-surgical management is preferred; however, if non-surgical management is not safe (such as in patients with sepsis or septic shock), or if patients stay in hospital for a longer period of time, surgery is mandatory [8].

The workflow to protect medical workers from COVID-19 infection is shown in Fig. 1. Following this workflow, no medical workers, staff, residents, nurses, or anesthesiologists were infected with COVID-19. The workflow shows preoperative COVID-19 swab testing, a single fixed transfer pathway, the shortest route of patient transfer, a PPE dressing and undressing guide, limitations of medical workers in the operating theater, closure of the operating room

**Table 2**

Compared of all service of Acute Care Surgery service on 2018, 2019, and 2020.

	1 April - 31 May 2020 N = 61	1 April - 31 May 2019 N = 123	1 April - 31 May 2018 N = 135	P-value
Death	1 (1.64)	1 (0.81)	0	0.332
Complication	6 (9.84)	8 (6.50)	15 (11.11)	0.432
Consultation time(min): median(iqr)	10 (15)	12 (8)	15 (15)	<b>0.033</b>
Time to operation room (min): median(iqr)	660 (472.5)	480 (315)	420 (525)	<b>0.011</b>
Operative time (hrs): median (iqr)	60 (75)	67.5 (67)	75 (78)	0.219



door at all times during surgery, use of equipment only in the operating theater to reduce the spread of infection, and the requirement to shower after undressing from PPE. Triage and hemodynamic management of patients are paramount [8] as they help surgeons to decide whether or not to operate. Triage provides the most efficient tool to prioritize what needs to be managed first and to provide treatment during the COVID-19 pandemic. Triage is affected by mass casualty incidents, such as the COVID-19 pandemic [11]. The four phases of the disaster cycle apply to the COVID-19 outbreak: mitigation, preparedness, response, and recovery [11]. From good triage, we performed active surveillance of COVID-19 for emergency and urgent surgical conditions, even in asymptomatic respiratory cases. Surveillance included preoperative COVID-19 swab testing and waiting for the results before performing surgery in 28 patients (46.67%). All 28 patients tested negative for COVID-19. This helped to minimize the use of PPE and protect medical workers from infection.

Triage allowed surgeons to perform emergency surgery without waiting for preoperative COVID-19 swab test results in five cases (8.33%) due to life-threatening peritonitis with septic shock in two cases (4.26%), trauma with profound hemorrhagic shock (grade 4) in three cases (23.08%), penetrating trauma of the small bowel and colonic injury, and neurologic trauma impending brain herniation. This demonstrates the efficiency of triage according to American College of Surgeons guidelines [8].

The total number of patients using the Acute Care Surgery service during the COVID-19 pandemic lockdown decreased by around 50% in 2020 (135 cases in 2018 vs. 123 cases in 2019 vs. 61 cases in 2020). Compared with the previous year, the consultation time during the COVID-19 pandemic lockdown period was significantly shorter compared with previous years ( $p = 0.033$ ). This decrease was attributable to our strategy to conserve resources by avoiding a refer-in approach and encouraging a refer-out approach to hospitals near to patients' places of residence, which led to a shorter consultation time. Some patients were afraid of COVID-19 infection so they did not want to attend hospital unless it was for an emergency condition. This fear has also affected blood donation, with a shortage of blood components for resuscitation replacement. Patrini et al. reported a decline in the overall number of urgent cases in multiple regions in Italy; however, more severe presentation was observed due to delays in diagnosis [12]. We had a shorter consultation time due to a decrease in the number of patients, which means that morbidity and mortality rates were not significantly different compared with previous years. The number of trauma cases was no different because trauma does not depend on the COVID-19 situation. We had only one patient who was highly suspected of having COVID-19; however, the patient's swab test results were negative. Thus, no patients with conditions requiring emergency surgery had COVID-19 during the lockdown period.

The average time taken to receive the preoperative COVID-19 test report was 227.26 min (3.79 h). Waiting for preoperative COVID-19 swab test results significantly increased the time to surgery compared with previous years of service (660 min in 2020;  $p = 0.011$ ), but morbidity and mortality were not significantly different. Urgent cases were managed as outpatients, including patients with hemorrhoids; uncomplicated diverticulitis; or minor trauma, such as extremity laceration wounds in seven cases (11.67%). This helped to minimize the risk of exposure to COVID-19. From triage, non-operative management was successful in 10 cases of non-complicated appendicitis (16.67%). These patients had no fecalith and no signs of perforation on abdominal computed tomography. Acute cholecystitis was also only mild. The surgical duration during the COVID-19 pandemic was not different compared with previous years despite a substantial amount of preparation; a limited number of medical workers in the operating

theater; and limited equipment, which had to be prepared in the operating theater to minimize access until surgery was concluded. The limitation of pandemic period is shortness of personal protective equipments for surgeon, anaesthesiologist, nurses, and medical workers can overcome by strictly screening of history for PUI patients, good triage of which patients can perform non-operative management and preoperative COVID-19 swab testing before start operation to choose the level of personal protective equipments.

## 5. Conclusion

The COVID-19 pandemic has affected management of patients with emergency or urgent surgical conditions. Effective triage to guide management and preoperative COVID-19 swab testing to adjust resources result in good outcomes. Even though the time to surgery was longer during the COVID-19 pandemic, morbidity and mortality rates were unaffected. In patients with life-threatening conditions, surgery without waiting for COVID-19 swab test results is inevitable. Thus, effective PPE should be enforced. Our results suggest that waiting for preoperative COVID-19 swab test results before performing surgery is safe for patients and medical workers.

## 6. Strength and limitation

- Our pre-operative testing is results in a good outcome with compare to previous year of the service.
- Limitation is a small number of participants due to limit of service in pandemic lockdown period

## Ethical approval

Ethics approval was permitted from Ethical committee of Mahidol University.

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## Author contribution

Chonlada Krutsri has made substantial contributions to the conception, design of the work, interpretation of data, has drafted the work, and revised it.

Pongsasit Singhatas has made substantial contributions to the conception, interpretation of data, and substantively revised it.

Preeda Sumritpradit have made the acquisition and interpretation of data.

Tharin Thampongsa have made the acquisition and interpretation of data.

Samart Phuwapraisirisan have made the acquisition and interpretation of data.

Goragoch Gesprasert have made the acquisition and interpretation of data.

Jakrapan Jirasiritham have made the acquisition and interpretation of data.

## Conflict of interest statement

The authors declare that they have no conflict of interest.

## Guarantor

Dr.Chonlada Krutsri is the one who had full responsibility for this work ([somzaisom@icloud.com](mailto:somzaisom@icloud.com)).

## Research registration number

1. Registry used: Thai Clinical Trials Registry.
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## Appendix A. Supplementary data

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