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Impact of acute care surgery model in aspects of patients with upper gastrointestinal hemorrhage: result from a single tertiary care center in Thailand

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ABSTRACT

Background Even though an acute care surgery (ACS) model has been implemented worldwide, there are still relatively few studies on its efficacy in developing countries, which often have limited capacity and resources. To evaluate ACS efficacy in a developin country, we compared mortality rates and intervention timeliness at a tertiary care center in Thailand among patients with an upper gastrointestinal hemorrhage (UGIH).

Methods This retrospective study compared two 24-month periods between pre-ACS and post-ACS implementations from July 1, 2014, to June 30, 2018. Medical records from consecutive patients with UGIH in the surgical department of Chonburi Hospital, Thailand, were reviewed. The primary outcome was UGIH mortality rate differences between pre-ACS and post-ACS implementations. Differences in complications rate, length of hospital stay (LOS), time to esophagogastroduodenoscopy (EGD) and proportion of patients undergoing esophagogastroduodenoscopy (%EGD) in the same admission were also analyzed using unpaired t-test and Fisher's exact test. Baseline characteristic differences between the pre-ACS and post-ACS periods were controlled for in multiple linear and logistic regression models.

Results A total of 421 patients were included (162 pre-ACS and 259 post-ACS). Results showed a mortality rate of 24% in post-ACS compared with 41% in pre-ACS period ($p<0.001$). Overall complications (38% vs 27%), LOS (6.4 days vs 5.6 days) and time to EGD (44 hours vs 25 hours) were also significantly reduced, whereas %EGD increased (70% vs 89%). After adjusting for covariates, patients in the post-ACS period had lower risk of death (OR 0.54, $p=0.040$), lower risk of developing respiratory complications (OR 0.52, $p=0.036$), higher chance of receiving EGD in the same admission (OR 2.94, $p<0.001$) and shortened time to EGD for 19 hours ($p<0.001$).

Discussion Our results provide evidence that ACS can be implemented to improve patient outcomes at medical centers in developing countries with limited resources.

Level of evidence Therapeutic/care management, level IV.

INTRODUCTION

The acute care surgery (ACS) model, which consisted of trauma, surgical critical care and emergency general surgery (EGS), was developed to solve the crisis of insufficient trauma surgeons due to an increased trend of surgeons specializing in the subspecialties.[1 2] The main objective of the ACS model was to promptly treat patients by having specific surgical teams on standby during daytime without prior scheduled services. Additionally, during after hours, most institutions also provide in-house resident coverage and attending on-call service.[3] However, there are some key differences among ACS models around the world. More structural ACS services have been established in North America, Europe and Australasia, including independent subunits and acute care wards, whereas in low-income countries like Africa, comprehensive ACS models have not yet been implemented. Furthermore, service coverage differs between countries. In the USA, ACS models operated by trauma surgeons cover both trauma and EGS cases, whereas in Canada, Europe, and Australasia, EGS services are provided only by general surgeons.[3 4]

During the past decade, ACS has been proven worldwide to bring multiple benefits, including an increase in work relative value units, without impacting elective operation,[2 5] decreases in overall mortality,[1 4] time to surgical evaluation,[4 6–8] time to operation,[4 6 8 9] complication rate,[4 10] length of hospital stay (LOS)[1 4 7 10] and hospital costs.[1 4 7 10] In Thailand, ACS models were recently implemented in selected medical centers, including Chonburi Hospital, the largest tertiary medical center in the eastern part of Thailand, which established its ACS on July 1, 2016. The Chonburi ACS team consists of surgeons, residents and interns who exclusively manage only EGS patients including timely consultations and inpatient services. Furthermore, 24/7 in-house resident and intern coverage is also provided. Currently, there are limited studies about the efficacy of ACS in middle-income country like Thailand. Therefore, this study was conducted by choosing one of the most common diseases treated by ACS, upper gastrointestinal hemorrhage (UGIH), to test the hypothesis that the ACS model would bring benefits to surgical quality of care by decreasing mortality rate and improving intervention timeliness compared with the previous general operation service model.

METHODS

Background of Chonburi Hospital Surgery Unit and UGIH management

Prior to ACS, the Chonburi Hospital Surgery Unit consisted of a general operation and trauma team. The general operation team was responsible for scheduled operations, as well as outpatient and inpatient services in which EGS consultation was the responsibility of surgeons who were assigned to outpatient services or minor operations. After the ACS model was introduced, the ACS team began to exclusively manage EGS patients, including ensuring delivery of timely consultations and inpatient services. The ACS team consisted of residents and interns on in-house 24-hour standby without any scheduled services during office hours and general surgeons on in-house standby during office hours and on-call during after-hours.

Patients with UGIH were treated by both surgeons and gastroenterologists, depending on the patients' condition. When patients with UGIH arrived at the hospital, emergency physicians performed initial resuscitation and assessment. If patients had unstable vital signs or were suspected of clinically active bleeding, surgeons would be consulted for emergency surgical interventions, including EGD, surgical exploration or Sengstaken-Blakemore tube insertion. Patients who were stable and without any signs of clinically active bleeding would be admitted to the internal medicine department to be scheduled later for an elective EGD by gastroenterologists. Due to limited resources and manpower, after-hours EGD is not provided and Sengstaken-Blakemore tube insertion or emergency exploration is performed for these patients when needed.

Study design and setting

A retrospective cohort study was conducted using data from the inpatient International Classification of Diseases, 10th Revision, database of all consecutive patients with UGIH admitted in the surgical department of Chonburi Hospital, Thailand, from July 1, 2014, to June 30, 2018. This period included 2 years each during the pre-ACS and post-ACS implementation period. The ACS starting date was July 1, 2016. Patients excluded from the analysis were those who developed UGIH during admission, had an underlying disease of cancer, referred out before treatment completion or refused to complete the treatment, had incomplete initial vital signs or laboratory results at the emergency room, or already had prior treatment from other departments or hospitals before admission into the surgical unit.

Information on patients' baseline characteristics and initial management was collected, including age, gender, comorbidities (ie, chronic kidney disease, preadmission hepatic failure, cirrhosis, hepatitis, hypertension, diabetes, dyslipidemia, stroke, myocardial infarction, heart failure, hypertensive heart diseases and heart conductive disorders), principal and related diagnoses, initial vital signs, laboratory results at the emergency room and surgical interventions used for treatment. Primary outcome of the analysis was the mortality rate difference between the pre-ACS and post-ACS periods. Secondary outcomes included complication rate, LOS, time from admission to EGD (time to EGD) and proportion of patients undergoing esophagogastroduodenoscopy (%EGD) in the same admission.

Subgroup analysis based on Pre-endoscopic Rockall Score[11] and hemodynamic status defined as stable (heart rate (HR)<100 and systolic blood pressure (SBP)≥100), tachycardia (HR≥100 and SBP≥100) and hypotension (SBP<100) were also calculated.

Statistical analysis

Continuous data were reported using means with 95% CI, whereas categorical data were reported using count and percentage. Differences in mortality rate and secondary outcomes between pre-ACS and post- ACS period were tested for significance using the unpaired t-test and Fisher's exact test for continuous and categorical variables, respectively. Multiple logistic and linear regression were used to adjust for key covariates (demographic and/or clinical characteristics) due to baseline characteristic differences between pre-ACS and post-ACS samples. All analyses were performed using STATA V.14.

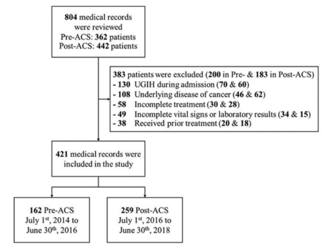

Figure 1 Population recruitment process. ACS, acute care surgery; UGIH, upper gastrointestinal hemorrhage.

RESULTS

A total of 804 patient records were reviewed. The study excluded 383 patients for the following conditions: 130 patients developed UGIH during admission; 108 patients had an underlying disease of cancer; 58 patients were referred to other hospitals before treatment completion or refuse to complete the treatment; 49 patients had incomplete initial vital signs or laboratory results at the emergency room; and 38 patients already had prior treatment from other departments or hospitals before admitted into the surgical unit. A total of 421 patients, 162 in the pre-ACS period and 259 in post-ACS period, were included in the study (figure 1).

Table 1 displays differences between the pre-ACS and post-ACS patient study populations. Patients in the post-ACS group were slightly older (51 in pre-ACS vs 53 in post-ACS, p=0.031) and less likely to be male (81% vs 72%, p=0.048). The post-ACS group had a higher percentage of hemodynamic stable patients compared with the pre-ACS patients (18% vs 34%, p<0.001). Laboratory results from the emergency room also showed that the pre-ACS group had lower hemoglobin levels (6.6 vs 7.7, p<0.001) and hematocrit (19.7 vs 22.8, p<0.001). Furthermore, they also had significantly higher prothrombin time, partial thromboplastin time and international normalized ratio (INR) compared with the post-ACS group. No statistical differences were found with patients' comorbidities, whereas the majority of the patients in both groups were diagnosed with cirrhosis (78% vs 71%, p=0.114). Pre-endoscopic Rockall Scores were slightly higher in the pre-ACS period (3.7 vs 3.4, p=0.030). The proportion of non-variceal UGIH was lower in the pre-ACS group (33% vs 53%), whereas the proportion of variceal UGIH were similar in both group (35% vs 32%). The cause of UGIH could not be identified in 33% and 15% of pre-ACS and post-ACS patients, respectively, because patients either died before EGD, did not undergo EGD in the same admission, or massive bleeding prevented the identification of the cause.

The crude mortality rate was significantly lower in the post-ACS period (41% vs 24%, p<0.001) (table 2). Furthermore, after categorizing patients based on their Pre-endoscopic Rockall Score and initial hemodynamic status at the emergency room, the post-ACS group had a lower mortality rate compared with the pre-ACS group with a Pre-endoscopic Rockall Score of 4 (p<0.001) but had no statistical differences in other score groups (figure 2). In addition, patients with tachycardia (hypovolemic shock stage 2) or hypotension (hypovolemic shock stages 3 and 4) had a lower mortality rate in post-ACS compared with pre-ACS period (40% vs 20%, p=0.011, and 50% vs 30%,

Table 1 Demographic and clinical characteristics of pre-ACS and post-ACS patients with UGIH

Characteristics	Pre-ACS (n=162) Mean (95% CI) or n (%)	Post-ACS (n=259) Mean (95% CI) or n (%)	P value
Demographic data			
Age (years)	51 (49 to 53)	53 (52 to 55)	**0.031***
Male	131 (81)	187 (72)	**0.048†**
Initial vital signs			
SBP	105 (100 to 110)	111 (107 to 114)	**0.038***
Diastolic blood pressure	61 (58 to 64)	69 (66 to 71)	**<0.001***
HR	101 (97 to 106)	99 (96 to 102)	0.378*
Hemodynamic status			**0.001†**
Stable (HR<100 and SBP≥100)	29 (18)	87 (34)	
Tachycardia (HR≥100)	63 (39)	89 (34)	
Hypotension (SBP<100)	70 (43)	83 (32)	
Laboratory results			
Hemoglobin	6.6 (6.2 to 7.0)	7.7 (7.3 to 8.0)	**<0.001***
Hematocrit	19.7 (18.7 to 20.7)	22.8 (21.9 to 23.7)	**<0.001***
Platelet	129 (117 to 142)×10³	133 (123 to 143)×10³	0.702*
PT	28.4 (23.6 to 33.2)	19.9 (18.3 to 21.6)	**<0.001***
PTT	49.6 (41.2 to 58.1)	36.1 (32.6 to 39.7)	**0.001***
INR	2.5 (2.0 to 3.0)	1.7 (1.6 to 1.9)	**<0.001***
BUN	28.1 (25.1 to 31.0)	32.1 (29.1 to 35.1)	0.078*
Creatinine	1.5 (1.3 to 1.7)	1.4 (1.2 to 1.6)	0.733*
eGFR	77.9 (70.9 to 84.8)	84.9 (78.9 to 90.9)	0.140*
Comorbidities			
Chronic kidney disease	61 (38)	86 (33)	0.401†
Hepatic failure (preadmission)	5 (3)	4 (2)	0.315†
Cirrhosis	126 (78)	183 (71)	0.114†
Hepatitis	21 (13)	45 (17)	0.271†
Hypertension	23 (14)	55 (21)	0.073†
Diabetes	20 (12)	49 (19)	0.080†
Dyslipidemia	2 (1)	10 (4)	0.141†
Stroke	2 (1)	8 (3)	0.329†
Cardiovascular comorbidities‡	5 (3)	7 (3)	>0.999†
Pre-endoscopic Rockall Score	3.7 (3.5 to 3.9)	3.4 (3.3 to 3.6)	**0.030***

*Unpaired t-test.
†Fisher's exact test.
‡Cardiovascular comorbidities included myocardial infarction, heart failure, hypertensive heart diseases and heart conductive disorders.
ACS, acute care surgery; BUN, blood urea nitrogen; eGFR, estimated glomerular filtration rate; HR, heart rate; INR, international normalized ratio; PT, prothrombin time; PTT, partial thromboplastin time; SBP, systolic blood pressure; UGIH, upper gastrointestinal hemorrhage.

p=0.013, respectively). Nevertheless, there was no statistical difference in the mortality rate among the hemodynamic stable patients between the two groups (table 3).

In terms of complications, overall complications (38% vs 27%, p=0.018), respiratory complications (23% vs 12%, p=0.004), pneumonia (6% vs 2%, p=0.030) and respiratory failure (20% vs 12%, p=0.017) results showed significantly lower prevalence in the post-ACS group (table 2). After subgrouping patients based on their hemodynamic status, only patients with tachycardia had statistically lower respiratory complications (30% vs 12%, p=0.012) and pneumonia (11% vs 2%, p=0.034) in the post-ACS period, whereas there were no differences in the complications rate between the pre-ACS and post-ACS periods among stable and hypotensive patients (table 3).

Measures of health use (LOS) and intervention timeliness (time to EGD) showed significant decreases from 6.4 to 5.6 days (p=0.033) and 44 to 25 hours (p<0.001), respectively (table 2). In addition, the proportion of patients who underwent EGD in the same admission (%EGD) rose from 70% during the pre-ACS period to 89% after ACS implementation (p<0.001). After subgrouping patients based on their hemodynamic status, patients with tachycardia and hypotension had higher %EGD (71% vs 91%, p=0.002, and 64% vs 84%, p=0.005, respectively) and shortened time to EGD (45 hours vs 27 hours, p=0.002, and 47 hours vs 26 hours, p=0.010, respectively) in post-ACS period, but there were no differences in both outcomes for hemodynamic stable patients (table 3).

Table 2 Primary and secondary outcomes between pre-ACS and post-ACS periods

Outcomes	Pre-ACS (n=162) Mean (95% CI) or n (%)	Post-ACS (n=259) Mean (95% CI) or n (%)	P value
Crude mortality rate	66 (41)	62 (24)	**<0.001***
LOS (days)	6.4 (5.6 to 7.3)	5.6 (5.2 to 6.0)	**0.033†**
Time to EGD (hours)	44 (35 to 53)	25 (22 to 29)	**<0.001†**
%EGD	113 (70)	230 (89)	**<0.001***
Complications			
Overall complications	62 (38)	70 (27)	**0.018***
Acute renal failure	41 (25)	53 (20)	0.279*
Septicemia	8 (5)	13 (5)	>0.999*
Hepatic failure (complication)	7 (4)	6 (2)	0.260*
Respiratory complications‡	38 (23)	32 (12)	**0.004***
Pneumonia	10 (6)	5 (2)	**0.030***
Respiratory failure	33 (20)	30 (12)	**0.017***
Cardiovascular complications§	4 (2)	5 (2)	0.738*

*Fisher's exact test.
†Unpaired t-test.
‡Respiratory complications included pneumonia and respiratory failure.
§Cardiovascular complications included acute myocardial infarction, acute heart failure and acute heart conductive disorders.
ACS, acute care surgery; %EGD, proportion of patients undergoing esophagogastroduodenoscopy; EGD, esophagogastroduodenoscopy; LOS, length of hospital stay.

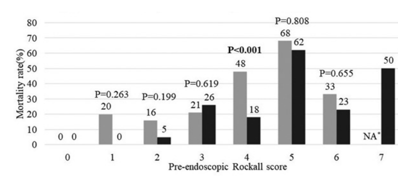

Figure 2 UGIH mortality rate stratified by Pre-endoscopic Rockall Score mortality rate difference between pre-ACS and post-ACS periods in each score group was tested for significance using Fisher's exact test. *No patients in the pre-ACS group had Pre-endoscopic Rockall Score of 7. ACS, acute care surgery; UGIH, upper gastrointestinal hemorrhage.

Table 3 Primary and secondary outcomes between pre-ACS and post-ACS periods by hemodynamic status

	Stable			Tachycardia			Hypotension		
Outcomes	Pre-ACS N=29	Post-ACS N=87	P value	Pre-ACS N=63	Post-ACS N=89	P value	Pre-ACS N=70	Post-ACS N=83	P value
Mortality, n (%)*	6 (21)	19 (22)	>0.999	25 (40)	18 (20)	**0.011**	35 (50)	25 (30)	**0.013**
LOS (days) (95% CI)†	5.5 (3.4 to 7.5)	5.5 (4.9 to 6.2)	0.915	6.5 (5.3 to 7.6)	5.4 (4.8 to 6.0)	0.066	7.0 (5.6 to 8.5)	5.9 (5.1 to 6.6)	0.109
Time to EGD (hours) (95% CI)†	37 (21 to 53)	24 (17 to 30)	0.063	45 (33 to 57)	27 (21 to 32)	**0.002**	47 (29 to 64)	26 (19 to 32)	**0.010**
%EGD, n (%)*	23 (79)	79 (91)	0.111	45 (71)	81 (91)	**0.002**	45 (64)	70 (84)	**0.005**
Complications (%)*									
Overall complications	6 (21)	19 (22)	>0.999	27 (43)	24 (27)	0.055	29 (41)	27 (33)	0.313
Acute renal failure	2 (7)	17 (20)	0.151	18 (29)	15 (17)	0.110	21 (30)	21 (25)	0.587
Septicemia	1 (3)	4 (5)	>0.999	3 (5)	5 (6)	>0.999	4 (6)	4 (5)	>0.999
Hepatic failure (complication)	0 (0)	4 (5)	0.571	3 (5)	0 (0)	0.069	4 (6)	2 (2)	0.413
Respiratory complications‡	5 (17)	7 (8)	0.171	19 (30)	11 (12)	**0.012**	14 (20)	14 (17)	0.677
Pneumonia	1 (3)	0 (0)	0.250	7 (11)	2 (2)	**0.034**	2 (3)	3 (4)	>0.999
Respiratory failure	5 (17)	7 (8)	0.171	15 (24)	11 (12)	0.081	13 (19)	12 (14)	0.518
Cardiovascular complications§	0 (0)	2 (2)	>0.999	3 (5)	0 (0)	0.069	1 (1)	3 (4)	0.626

*Fisher's exact test.
†Unpaired t-test.
‡Respiratory complications included pneumonia and respiratory failure.
§Cardiovascular complications included acute myocardial infarction, acute heart failure and acute heart conductive disorders.
ACS, acute care surgery; %EGD, proportion of patients undergoing esophagogastroduodenoscopy; EGD, esophagogastroduodenoscopy; LOS, length of hospital stay.

Due to differences in baseline characteristic between pre-ACS and post-ACS populations, we ran multiple logistic and linear regression models that controlled for age, gender, hemodynamic status, hemoglobin level, platelet, INR and comorbidities as covariates. Some covariates were omitted due to problems with multicollinearity or a low number of occurrences in the sample. After adjusting for covariates, patients in the post-ACS period had lower risk of death (OR 0.54, 95% CI 0.30 to 0.97; p=0.040), lower risk of developing respiratory complications (OR 0.52, 95% CI 0.29 to 0.96; p=0.036) and shortened time to EGD (mean reduction 19 hours, 95% CI −27 to −10; p<0.001). Moreover, patients in the post-ACS period also had a higher chance of receiving EGD in the same admission (OR 2.94, 95% CI 1.67 to 5.19; p<0.001) (table 4).

Outcome analysis for patients who underwent Sengstaken-Blakemore tube insertion or emergency exploration could not be performed because all patients in the post-ACS period only underwent EGD, and the two hypotensive patients during the pre-ACS period were sent for emergency exploration, and both died during hospitalization. Their diagnoses were esophageal varices and peptic ulcer, respectively.

DISCUSSION

The introduction of the ACS model at Chonburi Hospital has resulted in rapid assessment and treatment of patients and produced better outcomes, such as a decrease in mortality, complications and time to surgical intervention, which in this study was EGD, as selected in previous studies.[1 4 8–10 12] When performing subgroup analysis controlling for the initial hemodynamic status, there was an increase in %EGD and a decrease in time to EGD for patients with tachycardia and hypotension during the post-ACS period, which resulted in reduced mortality for these two time-sensitive groups. This result highlighted the benefits of prompt attention to patients with UGIH by the ACS team. The delay in assessment due to busy routine work schedules can often worsen patient outcomes. Multiple studies have showed that the ACS model, given proper human

Table 4 Unadjusted and adjusted effect of ACS compared between post-ACS and pre-ACS periods on significant outcomes

Outcomes	**Unadjusted OR (95% CI)**	**P value**	**Adjusted OR (95% CI)**	**P value**
Mortality rate*	0.46 (0.30 to 0.70)	<0.001	0.54 (0.30 to 0.97)	0.040
Overall complications*	0.60 (0.39 to 0.91)	0.016	0.72 (0.43 to 1.21)	0.215
Respiratory complications*	0.46 (0.27 to 0.77)	0.003	0.52 (0.29 to 0.96)	0.036
Pneumonia*	0.30 (0.10 to 0.89)	0.030	0.29 (0.07 to 1.14)	0.076
Respiratory failure*	0.51 (0.30 to 0.88)	0.015	0.63 (0.34 to 1.16)	0.138
%EGD*	3.44 (2.06 to 5.74)	<0.001	2.94 (1.67 to 5.19)	<0.001
Outcomes	Unadjusted Mean difference (95% CI)	P value	Adjusted Mean difference (95% CI)	P value
LOS (days)†	−0.8 (−1.6 to −0.1)	0.033	−0.4 (−1.2 to 0.3)	0.272
Time to EGD (hours)†	−19 (−27 to −11)	<0.001	−19 (−27 to −10)	<0.001

Adjusted for age, gender, hemodynamic status, hemoglobin, platelet, international normalized ratio and all comorbidities.
*Multiple logistic regression.
†Multiple linear regression.
%EGD, proportion of patients undergoing esophagogastroduodenoscopy; EGD, esophagogastroduodenoscopy; LOS, length of hospital stay.

resource allocation to staff work schedules, can improve the efficiency of the surgical team by increasing total case volume for ACS without interrupting scheduled elective operations and improving management of operating room resources.[2 5 13]

After implementation of the ACS model at Chonburi Hospital, multiple quality indicators measuring health use and intervention timeliness improved, such as an increase in the proportion of patients who underwent EGD and reduced time from admission to EGD. However, there was no improvement in LOS in our study. One possible explanation is that Chonburi Hospital patients with variceal bleeding, which was approximately one-third of total patients with UGIH in both time periods, underwent a 5-day somatostatin-analogue protocol, regardless of their disease severity.

The limitation of this study was the differences in baseline characteristics between pre-ACS and post-ACS periods. The pre-ACS period had a higher proportion of hypotensive patients, lower hemoglobin level and worse coagulopathy, which can be implied as higher severity of UGIH. Furthermore, we also saw the difference in the cause of bleeding distribution between these two groups, in which the pre-ACS period had a lower proportion of non-variceal bleeding patients. A possible explanation for the differences seen in the baseline characteristics was that after introduction of the ACS model, there was an increase in ACS team consultation to evaluate patients whom ER physicians suspected as having active hemorrhage, even though their hemodynamic status was still stable, instead of putting the patients in observation or admission to the internal medicine department. Although the analysis was adjusted for all identified covariates, other unidentified differences may still affect the results. Another limitation was a large proportion of patients who did not undergo a diagnostic EGD in both periods; therefore, the cause of bleeding could not be integrated into the analysis, which could significantly change the outcome of the study since this group of patients had a wide range of UGIH severity varying from very mild to mortality before EGD.

CONCLUSION

The ACS model at Chonburi Hospital brought an improvement to many aspects of patient outcomes, despite the hospital's limited resources both in terms of human capital and equipment. Therefore, the ACS model should be considered for adoption by other medical centers, both in Thailand and in other low-income countries which have a setting similar to that of Chonburi Hospital, to improve the quality of care for its patients.

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Patient consent for publication Not required.

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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