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Outcomes in emergency surgery following the implementation of an acute care surgery model: a retrospective observational study

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Purpose: Over the past 3 years, approximately 23,000 emergency surgeries were performed annually in South Korea, accounting for >1% of all surgeries nationwide. With the growing necessity for treating these emergency cases with dedication and proficiency, acute care surgery (ACS) teams were appointed at various hospitals. Regarding the implications of the ACS team, many studies showed promising results with a shorter time from the emergency department (ED) to the operating room (OR), shorter length of stay, and fewer complications. This study aimed to demonstrate the overall effect of ACS implementation at a single institution in South Korea.
Methods: This was a single-center, retrospective observational study. Patients aged >18 years who visited the emergency room and received emergency surgery between July 2014 and December 2016 (pre-ACS) and between July 2017 and December 2019 (post-ACS) were included.
Results: Among 958 patients, 497 were in the pre-ACS group and 461 in the post-ACS group. After propensity score matching by age, sex, underlying disease, and Emergency Surgery Acuity Score, 405 patients remained in each group. Our analysis showed a reduction in time from ED presentation to operation (547.8 ± 401.0 minutes *vs*. 476.6 ± 313.2 minutes, P = 0.005) and complication rates (24.7% *vs*. 16.8%, P < 0.001) in the post-ACS group. There were no significant differences in total operation duration, length of hospital stay, and mortality between the groups.
Conclusion: As expected, time from ED to OR and complication rates were significantly reduced in the post-ACS group. Implementing an ACS team dedicated to emergency surgery provides better clinical outcomes.
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Key Words: Acute care surgery, Complication, Emergency general surgery, General surgery

INTRODUCTION

The acute care surgery (ACS) model has been heralded as a revolutionary step forward in acute surgical care compared with the traditional on-call (TOC) model. Although the quality of acute surgical care has improved over the years owing to the requirement for prompt initiation of treatment of acutely ill surgical patients, the TOC model had its limitations. This model involved a rotating pool of surgeons in charge of all emergency surgical caseloads in addition to their elective duties [1]. Consequently, the surgeon on call was often unavailable, delaying most emergency surgeries until the operating room (OR) was available after hours. Alternatively, patients were inevitably transferred to other facilities. In response to the

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lack of dedicated and well-organized service, the ACS model was developed in the early 2000s in the United States and was quickly adopted in most institutions offering emergency surgical care [2]. This model involves a dedicated surgical team comprising surgeons, residents, and nursing staff not involved in other services. This focused set of resources and infrastructure aims to provide round-the-clock care for all surgical emergencies [3,4].

The ACS model has been credited with improving access to care, reducing surgical complications, and improving patient outcomes [5]. In addition, ACS has been shown to reduce costs associated with caring for patients requiring urgent and emergent procedures [6]. The ACS model is associated with reducing the length of hospital stays and medical expenses [7]. Interestingly, one study analyzed the effects of handover on the quality of care in the ACS model and found no difference in complication rates or the lengths of hospital stay, thus assuring the safety of the patients in this model [8]. Alternatively, as the ACS model dictates multiple medical personnel working in shifts, work satisfaction was higher with minimal risk of patient hazard [9]. The ACS model with dedicated beds and ORs must be instrumental in changing the cultural aspect of the traditional notions regarding emergency surgeries [10]. Overall, this model has been shown to improve access to care and outcomes and reduce surgical complications while decreasing costs associated with emergency surgical care.

The first ACS model was designed by the American Association for the Surgery of Trauma (AAST); many countries followed and adopted the aims provided by the AAST [2]. The ACS model is a branch of general surgery that integrates surgical critical care, trauma, and emergency general surgery. This system involves having a surgical specialist on-site at the hospital, responsible for patient treatment and ready to handle emergency situations. In many countries implementing the ACS model, the components comprise a dedicated surgical service covering all non-trauma emergency surgery, daytime on-site attending coverage, exemption from elective duties, and 24-hour emergency department (ED) coverage by dedicated residents. Round-the-clock on-site attending coverage is observed only in the United States and Taiwan, and exclusive ACS wards have been observed in the United Kingdom, Sweden, South Africa, and Singapore [11]. Although the ACS model is in demand in South Korea, only a handful of hospitals can afford to install and sustain it due to a lack of medical personnel, resources, systems, and insurance policies [12].

This study aimed to analyze whether the ACS model showed better clinical outcomes than the TOC model on implementation in a single institution in emergency general surgery.

METHODS

This was a retrospective cohort study including patients with acute surgical abdomen requiring emergency surgery at a single institution, Asan Medical Center. It is one of the biggest hospitals in South Korea, with >2,700 beds, >100,000 patients presenting to the ED annually, and hosting >60,000 surgeries every year. Patients were divided into the pre-ACS group (between July 2014 and December 2016) and post-ACS group (between July 2017 and December 2019). As the ACS model was implemented at our institution in January 2017, the first 6 months of 2017 were deemed a transition period and thus excluded. At our hospital, the ACS team consists of 5 general surgeons with advanced training in colorectal or hepatobiliary surgery. These surgeons work in rotation and are present at the hospital 24 hours a day, 365 days a year, providing medical treatment. This dedicated team is responsible for treating surgical patients who visit the emergency room (ER) and performing emergent general surgeries. There is no separate operation room or anesthetists dedicated to emergency surgery. For patients who require intensive care unit (ICU) care after surgery, the surgical ICU handles postoperative care, with an intensivist stationed at the hospital at the hospital 24/7. Also, the ACS team has 2 surgical residents and no dedicated nurses.

The inclusion criteria were patients >18 years of age who presented to the ED with acute surgical abdomen and had surgery immediately before being admitted to the ward. The exclusion criteria were as follows: patients <8 years of age, those who underwent emergency surgery while admitted in departments other than surgery, those treated conservatively in the ward before deciding to undergo surgery, and patients who had previously undergone transplant (i.e., heart, lung, liver, kidney, or pancreas) or any type of vascular surgery. The types of surgery were not limited to any single surgery and any emergency surgery due to acute surgical abdomen was included. The primary outcome was the time taken from the ED admission to the time of arrival at the OR. The secondary outcomes were time taken from the ED admission to the decision for admission by the surgeon, length of hospital stay, length of ICU stay, discharge route, reoperation during the hospital stay, readmission within 30 days after discharge, complication rates, and mortality rates. We excluded patients who had worsened due to cancer progression or patients who had a sufficient possibility of recovery but were transferred from the hospital due to patient or family reasons from mortality. The time taken to get to the OR was measured based on the time recorded upon entering the OR from the time recorded upon presentation to the ED. Time from presentation to the ED to the decision of admission was measured based on the time recorded when a physician issued a confirmation of admission. The Emergency Surgery Acuity Score (ESAS) [13] was collected for the prediction of mortality, and postoperative complications were classified using the Clavien-Dindo classification system [14]. The data was obtained from the discharge summaries and progress notes.

Propensity score (PS) matching analysis was performed to reduce the effect of selection bias and potential confounding between the 2 groups. To perform PS matching analysis, adjustments were made for age, sex, operation type, Charlson Comorbidity Index (CCI), ESAS, and the presence of sepsis and shock. In the PS matching analysis, age, CCI, and ESAS were treated as continuous variables; sex (male, female) and the presence of sepsis and shock were treated as dichotomous variables; and operation type (open surgery, laparoscopic surgery, others) was treated as a ternary variable. One-to-one PS matching was performed by nearest neighbor matching with a caliper width of 0.1 multiplied by the standard deviation of the linearly transformed PS. Standardized differences of less than 10.0% for a given covariate indicate a relatively small imbalance.

Statistical analysis

The chi-square test or Fisher exact test was used for categorical data, and the independent samples t-test and Mann-Whitney U-test were used for continuous data. A P-value of <0.05 was considered statistically significant. Statistical analyses were conducted using R software ver. 4.0.3 (The R Foundation).

Ethics statement

The Institutional Review Board of the National Evidence-Based Healthcare Collaborating Agency approved this study (NECA-IRB number: NECAIRB22-004) and waived the requirement for informed consent. Electronic medical records were used to collect data retrospectively.

RESULTS

We identified a total of 958 patients in this study, among whom 497 were in the pre-ACS group and 461 in the post-ACS group (Table 1). There were statistically significant differences between groups in age, ESAS, major organ involvement, cause of emergency surgery, and the department performing surgery. The mean age was 55.9 and 59.1 years in the pre- and post-ACS groups, respectively. ESAS was significantly higher in the post-ACS group than in the pre-ACS group (4.3 ± 3.3 *vs.* 3.8 ± 3.1, respectively). Although there were statistically significant differences, the small bowel was the most affected organ, and perforation was the most common cause of emergency surgery in both groups. PS matching identified 405 matched pairs. After PS matching, the baseline characteristics of the 2 groups were balanced (P > 0.05 for most variables) in the overall cohort (Table 2).

Analysis of PS-matched groups showed notable differences in several areas (Table 3). Time from presentation to the ED to arrival in the OR was much shorter in the post-ACS group than in the pre-ACS group (476.6 ± 313.2 minutes *vs.* 547.8 ± 401.0 minutes, P = 0.005). Similarly, we observed that the time to decide on surgery was shorter in the post-ACS group than in the pre-ACS group (292.4 ± 232.7 minutes *vs.* 352.3 ± 302.5 minutes, P = 0.002). Compared with the pre-ACS group, the post-ACS group had fewer readmissions within 30 days after hospital discharge (1.7% *vs.* 4.9%, P = 0.011), although reasons for readmission were not investigated. Regarding postoperative complication rates, the post-ACS group had more mild complications than did the pre-ACS group (2.5% *vs.* 12.6%, P < 0.001), while there were no differences in other severity groups. As for when the surgery was performed, the post-ACS group underwent more weekend surgeries (47.7% *vs.* 34.3%, P < 0.001) and fewer weekday nighttime surgeries (28.4% *vs.* 44.7%, P < 0.001) than those of the pre-ACS group. The results were similar, even excluding appendicitis cases, with a reduction in time from the ED admission to the OR and in time to decision in the ER (Supplementary Table 1). There were no statistically significant differences in in-hospital mortality between the groups. A subgroup analysis was performed on patients admitted to the ICU (Supplementary Table 2). There was no statistical difference in the time taken from ER admission to the OR in the 2 groups. Postoperative complications were significantly lower in the post-ACS group.

Clinical outcomes were analyzed according to the time that the surgery was performed (Supplementary Table 3). During weekday daytime, it took the longest time from presentation to the ED to arrival in the ER, and emergency surgeries were performed more quickly during weekday nights and weekends. Surgery was performed more quickly at all time periods in the post-ACS group than in the pre-ACS group.

DISCUSSION

Since the introduction of the ACS model in the United States in the early 2000s, although different in structure and components between countries, it has been widely accepted as a replacement for the TOC model for providing prompt care in non-trauma emergency surgery [11]. The ACS model has reduced mortality and complication rates, time until operation, and medical expenses [15-17]. In a meta-analysis of 27 studies, implementing the ACS model improved the clinical and financial outcomes of emergency surgical cases in surgeries, such as acute appendicitis, acute cholecystitis, and inguinal hernia [15]. Regarding acute appendicitis, one study reported that the ACS model significantly decreased the time to operation, rupture rate, complication rate, and length of hospital stay [18]. Although various studies have examined the

Table 1. Baseline characteristics of the patients (n = 958)

Characteristic	Pre-ACS group (n=497)	Post-ACS group (n=467)	P-value
Age (yr)	55.9 ± 16.0	59.1 ± 15.9	0.002*
Male sex	292 (58.8)	273 (59.2)	0.883
Cause of diagnosis			0.075
Non-malignancy	352 (70.8)	350 (75.9)	
Malignancy	145 (29.2)	111 (24.1)	
Operation type			0.120
Open surgery	351 (70.6)	305 (66.2)	
Laparoscopic surgery	139 (28.0)	142 (30.8)	
Others	7 (1.4)	14 (3.0)	
Charlson Comorbidity Index	2.1 ± 2.3	2.3 ± 2.3	0.074
ESAS	3.8 ± 3.1	4.3 ± 3.3	0.012*
APACHE II score[a)]	18.6 ± 8.7	16.0 ± 8.0	0.014*
Sepsis at admission	88 (17.7)	88 (19.1)	0.581
Shock at admission	43 (8.7)	50 (10.9)	0.252
ICU admission	120 (24.1)	143 (31.0)	0.017*
Involved major organ			0.001*
Stomach	22 (4.4)	10 (2.2)	
Small intestine	224 (45.1)	237 (51.4)	
Large intestine	97 (19.5)	121 (26.3)	
Gall bladder	7 (1.4)	4 (0.9)	
Appendix	124 (25.0)	71 (15.4)	
Others	23 (4.6)	18 (3.9)	
Causes of emergency surgery			0.046*
Obstruction	106 (21.3)	119 (25.8)	
Perforation	161 (32.4)	172 (37.3)	
Ischemia/Infarct	46 (9.3)	47 (10.2)	
Hernia	26 (5.2)	19 (4.1)	
Trauma	13 (2.6)	6 (1.3)	
Acute appendicitis	125 (25.2)	82 (17.8)	
Others	20 (4.0)	16 (3.5)	
Divisions performing surgery			<0.001*
ACS	35 (7.0)	311 (67.5)	
Upper GI (ST)	99 (19.9)	55 (11.9)	
Lower GI (CRS)	229 (46.1)	75 (16.3)	
Hepatobiliary (HBP)	90 (18.1)	17 (3.7)	
Others (breast, endocrine, etc.)	44 (8.9)	3 (0.7)	

Values are presented as number only, mean ± standard deviation, or number (%).
ACS, acute care surgery; ESAS, Emergency Surgery Acuity Score; APACHE II, Acute Physiology and Chronic Health Evaluation II; ICU, intensive care unit; GI, gastrointestinal; ST, stomach surgery; CRS, colorectal surgery; HBP, hepato-biliary-pancreatic surgery.
[a)]In ICU admitted 263 patients.
*$P < 0.05$.

effect of the ACS model in single disease entities such as acute appendicitis, this is the first study to describe the impact of the ACS model in the context of all emergency abdominal surgeries.

Our study has shown a reduction in time from presentation to the ED to the OR, like previous studies that reported similar results [17]. As discussed earlier, the problem with the TOC model was that the on-call surgeons were often unavailable during the daytime due to elective surgeries and outpatient clinical sessions. As a result, when patients came to the ED during the daytime, they often had to wait until the on-call surgeons became available after their daytime duties ended. Such delay in examination by surgeons, who could solely decide whether to operate, delayed the actual decision and the time to the surgery. In contrast, the ACS model mandates that board-certified general surgeons be in-house round-the-clock, readily available to examine the patients presenting to the ED when consulted. With the round-the-clock availability of dedicated surgeons, compared with the pre-ACS group, time from the ED to the OR was successfully reduced in the post-ACS group, which was consistent with the result that the time from the ED admission to the decision for surgery was also reduced in the post-ACS group. With the availability of ACS surgeons on-site to examine the patient when consulted after the primary survey in the ED, the decision time to admission and the time to the OR was quicker.

However, compared with previous studies, our study showed

Table 2. Baseline characteristics of the patients after propensity score matching (n = 810)

Characteristic	Pre-ACS group (n = 405)	Post-ACS group (n = 405)	P-value
Age (yr)	56.7 ± 15.9	58.4 ± 16.1	0.123
Male sex	241 (59.5)	238 (58.8)	0.830
Cause of diagnosis			0.937
Non-malignancy	295 (72.8)	296 (73.1)	
Malignancy	110 (27.2)	109 (26.9)	
Operation type			0.439
Open surgery	283 (70.0)	294 (72.6)	
Laparoscopic surgery	115 (28.4)	101 (24.9)	
Others	7 (1.7)	10 (2.5)	
Charlson Comorbidity Index	2.1 ± 2.4	2.3 ± 2.3	0.295
ESAS	4.0 ± 3.2	4.3 ± 3.3	0.195
APACHE II score[a)]	18.4 ± 8.5	15.9 ± 8.2	0.017*
Sepsis at admission	78 (19.3)	83 (20.5)	0.660
Shock at admission	39 (9.6)	47 (11.6)	0.362
ICU admission	107 (26.4)	132 (32.6)	0.054
Involved major organ			0.844
Stomach	8 (2.0)	10 (2.5)	
Small intestine	196 (48.4)	205 (50.6)	
Large intestine	93 (23.0)	99 (24.4)	
Gall bladder	5 (1.2)	4 (1.0)	
Appendix	87 (21.5)	71 (17.5)	
Others	16 (3.9)	16 (4.0)	
Causes of emergency surgery			0.668
Obstruction	92 (22.7)	97 (24.0)	
Perforation	141 (34.8)	155 (38.3)	
Ischemia/Infarct	41 (10.1)	45 (11.1)	
Hernia	20 (4.9)	16 (4.0)	
Trauma	10 (2.5)	6 (1.5)	
Acute appendicitis	88 (21.7)	72 (17.8)	
Others	13 (3.2)	14 (3.5)	
Divisions performing surgery			<0.001*
ACS	28 (6.9)	279 (68.9)	
Upper GI (ST)	77 (19.0)	40 (9.9)	
Lower GI (CRS)	203 (50.1)	68 (16.8)	
Hepatobiliary (HBP)	65 (16.1)	15 (3.7)	
Others (Breast, Endocrine, etc.)	32 (7.9)	3 (0.7)	

Values are presented as mean ± standard deviation or number (%).
ACS, acute care surgery; ESAS, Emergency Surgery Acuity Score; APACHE II, Acute Physiology and Chronic Health Evaluation II; ICU, intensive care unit; GI, gastrointestinal; ST, stomach surgery; CRS, colorectal surgery; HBP, hepato-biliary-pancreatic surgery.
[a)]In ICU admitted 239 patients.
*$P < 0.05$.

a significantly longer ED stay and time to the OR even after the implementation of the ACS model [5,17,19,20]. Such results may be because our institution does not reserve an exclusive OR dedicated solely to emergency surgeries, and as a high-volume center, finding a vacant OR during the daytime for emergency surgical cases is challenging. Therefore, even with dedicated ACS surgeons and ED working round-the-clock, surgeries tend to get delayed due to the unavailability of the OR. This phenomenon is consistent with our study's result, which showed the daytime surgeries to be relatively similar in both groups. The types of surgeries performed during the daytime did not differ significantly between the groups, and we can safely assume that the lack of a dedicated OR may account for this phenomenon.

Our study showed that the ACS model successfully reduced minor complication rates, which is in line with the results of previous studies [17,18,21]. Although the rate of serious complications requiring surgery or intervention were similar, mild complication rates were significantly lower in the post-ACS group, and there could be several explanations for this. As mentioned earlier, transitioning from the pre-ACS to the post-ACS model meant a change from on-call surgeons to surgeons on a rotation schedule, who were much less predisposed to fatigue. Although the quality of life and fatigue of surgeons have not

Table 3. Clinical outcomes between pre-ACS and post-ACS (n = 810)

Characteristic	Pre-ACS group (n = 405)	Post-ACS group (n = 405)	P-value
Primary outcome			
Time from the ER admission to the OR (min)	547.8 ± 401.0	476.6 ± 313.2	0.005*
Secondary outcome			
Operation time (min)	152.0 ± 63.7	146.2 ± 73.6	0.233
Period that the surgery was performed			<0.001*
Weekday daytime	85 (21.0)	97 (24.0)	
Weekday nighttime	181 (44.7)	115 (28.4)	
Weekend	139 (34.3)	193 (47.7)	
Length of hospital stay (day)	17.5 ± 18.0	15.5 ± 21.0	0.162
Length of ICU stay (day)	9.4 ± 16.1	8.0 ± 14.0	0.472
Time from the ER admission to decision (min)	352.3 ± 302.5	292.4 ± 232.7	0.002*
Reoperation during hospital stay	34 (8.4)	46 (11.4)	0.158
Readmission[a)]	20 (4.9)	7 (1.7)	0.011*
Clavien-Dindo classification			<0.001
No complication (0)	305 (75.3)	337 (83.2)	
Mild complication (I–II)	51 (12.6)	10 (2.5)	
Severe complication (III–V)	49 (12.1)	58 (14.3)	
In-hospital mortality	10 (2.5)	18 (4.4)	0.080

Values are presented as mean ± standard deviation or number (%).
ACS, acute care surgery; ER, Emergency room; OR, operating room; ICU, intensive care unit.
Weekday daytime, 7 am–6 pm; weekday nighttime, 6 pm–7 am; weekend, Saturday to Sunday.
[a)]Within 30 days after hospital discharge.
*P < 0.05.

been investigated in this study, and complication rates could be attributed to technical failure to some extent, a surgeon's fatigue can be a critical risk factor concerning complication rates. Further, as on-call surgeons in the pre-ACS group were fellows or junior attendants with less experience in emergency surgical cases, this could be another reason for higher complication rates compared with surgeons in the post-ACS group who had at least 3 to 5 years of experience in the field.

We also examined the results after excluding appendicitis cases as appendicitis cases are deemed relatively simple and their postoperative course routine compared with other surgeries. A similar result was observed even without the appendicitis cases, with reduced time from the ED presentation to the OR, reduced time from the ED presentation to the decision for surgery, and fewer mild complications and readmissions.

The limitation of this study lies in its retrospective nature and that it was a single-center study. First, owing to this study's retrospective nature, a PS matching was performed to compensate for the selection bias. Second, since the study criteria only included patients who went directly from the ED to the OR, this data might not represent all patients with acute abdomen who required surgery. Since this study focused on the time from ED admission to the OR, patients who were already hospitalized were not included. Third, since this was a single-center study, the characteristics of the hospital were reflected in the overall study results. The length of stay in the ED or the time taken for surgery may differ from those of other hospitals in South Korea or overseas. In particular, since our hospital is not a trauma center, the number of trauma patients was relatively small. In Korea, trauma centers are designated throughout the country and are responsible for treating severe trauma patients. Therefore, in this study, emergency general surgery patients accounted for a relatively larger number than trauma patients. Hence, a multicenter study is needed in the future.

In conclusion, this study was one of the few that explored the impact of the ACS model regarding all surgeries involved in a high-volume center. Based on this study, it is safe to state that the ACS model effectively reduces the time from the ED to the OR, reduces the time from the ED to a decision, and lowers complication rates.

SUPPLEMENTARY MATERIALS

Supplementary Tables 1–3 can be found via https://doi.org/10.4174/astr.2024.107.5.284.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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