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Impact of Enforcement of the Act to Improve Training Conditions and the Status of Medical Residents in Emergency Abdominal Surgery

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Purpose: In 2018, the Act to Improve Training Conditions and the Status of Medical Residents (AITR) was fully implemented in South Korea. This study aimed to investigate the effects of AITR implementation on the clinical outcomes of patients who underwent emergency abdominal surgery.

Materials and Methods: A total of 2571 patients who underwent emergency abdominal surgery after visiting the emergency room (ER) between 2015 and 2019 was included. Electronic medical records were retrospectively reviewed. In addition, a comparative analysis was performed for patient groups treated before and after AITR implementation.

Results: The median patient age was 48.0 years, and 49.2% of them were male. Appendicitis was the most common diagnosis (82.6%), followed by major abdominal emergencies (9.9%) and cholecystitis (7.5%). The median time from arrival to surgery was 439 min, and 52 (2.0%) patients died. A comparison of patients who underwent surgery before (pre-AITR; 1453, 56.5%) and after (post-AITR; 1118, 43.5%) AITR implementation revealed a significant difference in age, number of residents on a 24-h shift, and diagnosis. The time from ER arrival to surgery was not significantly longer after AITR implementation than before AITR implementation (434 min vs. 443 min, p=0.230). AITR was not a significant risk factor for mortality (p=0.225).

Conclusion: The time from ER arrival to emergency surgery did not increase significantly after AITR implementation, and there was no difference in the patients' clinical outcomes.

Key Words: Preceptorship, internship and residency, patient safety, work schedule tolerance, general surgery

INTRODUCTION

Since medical resident training began at Johns Hopkins Hospital in 1889, the education and work of residents have drawn focus in many countries.[1] People began to take interest in the working hours of medical residents after Libby Zion's death in 1984 at 18 years of age due to a resident's prescription error while he was on continuous duty.[2] Since then, attention has been paid to misdiagnosis and patient safety due to the heavy workload of residents. In 1999, New York City enacted a law that limits the working hours of residents to 80 h per week. In 2003, the Accreditation Council for Graduate Medical Education (ACGME) extended the law on resident working hours across the United States.[3]

Similarly, in 2010, a 9-year-old died due to an error in the administration route of chemotherapy in South Korea. With the enactment of the Patient Safety Law, also known as the "Jonghyun Law" there has been a growing interest in limiting the working hours of residents[4,5] to address concerns for the deterioration of patient safety due to an excessive workload and poor environment of medical residents in South Korea. In July 2015, a special law on the restriction of working hours for medical

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resident training was proposed. After several discussions, the law, officially called the Act to Improve Training Conditions and the Status of Medical Residents (AITR), was enacted in November 2017 and fully implemented in 2018.[6]

Prior to the enforcement of the AITR, there were studies on the introduction of an ideal method for limiting resident working hours and related patient outcomes. However, research after the implementation of AITR is limited.[5,7-9] In addition, studies on post- AITR data focusing on surgery are extremely rare. In this study, we hypothesized that the implementation of the AITR would have affected clinical outcomes in patients undergoing emergency abdominal surgery and that there would be an observable change in the time from emergency room (ER) arrival to emergency operation after AITR implementation. Accordingly, this study aimed to investigate the effects of the AITR on the clinical outcomes and time from ER arrival to surgery in patients who underwent emergency abdominal surgery.

MATERIALS AND METHODS

Patient selection and data collection

Our study included 3400 patients who underwent emergency abdominal surgery after visiting the emergency department of National Health Insurance Service Ilsan Hospital (NHISIH) between 2015 and 2019. The electronic medical records of the patients were retrospectively reviewed. A total of 2571 patients was enrolled, excluding patients under 18 years of age who underwent surgery >24 h after ER arrival and those who underwent surgery under local anesthesia. Patients with perianal abscesses and inguinal hernias were excluded (Fig. 1). Operations for patients with acute appendicitis and cholecystitis were considered minor emergency surgeries, while operations for conditions such as panperitonitis and bowel ischemia were considered major emergency surgeries.

Patient characteristics were compared between the patients who underwent surgery between 2015 and 2017 (pre-AITR) and those who underwent surgery between 2018 and 2019 (post-AITR). In addition, we analyzed the time from ER arrival to surgery, length of hospital stay, and death during hospitalization after AITR implementation. We confirmed the name of the resident on the 24-h shift based on the duty list submitted to the hospital. We confirmed initial laboratory test results and vital signs at the time of admission to the ER to establish the severity of disease; consequently, we performed a subgroup analysis according to the diagnosis.

Hospital setting

The present study was conducted at NHISIH, which is a secondary general hospital with 815 beds and is a medical resident training institution. The AITR has been applied in NHISIH since January 2018, limiting the working hours of residents to <80 h per week. Before the AITR was implemented, each resident worked 24-h shifts, three to four times a week, and after its implementation, each resident worked 24-h shifts, one to three times a week. The number of residents in the 24-h shift was determined according to the total number of residents and the day of the shift. Senior (3rd and 4th year) and junior (1st and 2nd year) residents were paired for a 24-h shift. From 7:00 am to 7:00 am the next day, the resident first examined the patient and then notified the on-call staff member. During the study period, day surgery was applied for surgery for appen-

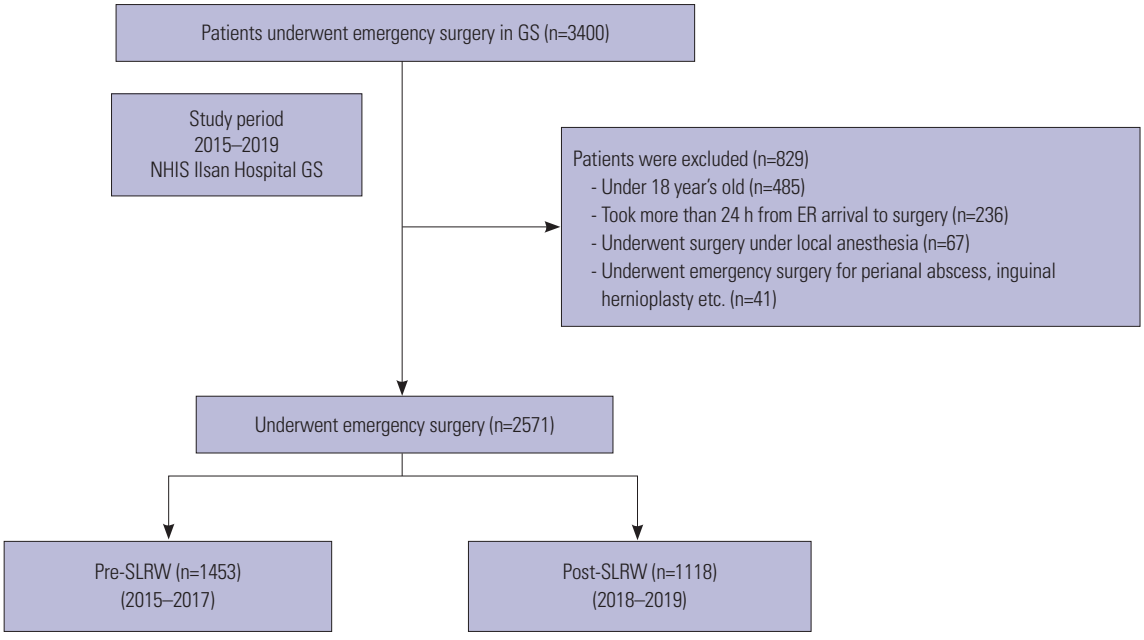

Fig. 1. Flow chart showing the number of patients who underwent emergency abdominal surgery. NHIS, National Health Insurance Service; ER, emergency room; GS, Department of General Surgery; SLRW, special law on restriction of working hours in training.

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dicitis and cholecystitis. However, the surgeries could be delayed considering whether there was elective surgery the next day. Therefore, the decision of surgery was entirely dependent on the on-call surgeon.

AITR

The core contents of the AITR are as follows: first, the working hours of a resident must not exceed 80 h per week, on average, for 4 weeks. Second, the maximum continuous training is limited to 36 h. Third, a minimum of 10 h of rest should be guaranteed between consecutive training sessions. Fourth, leave pertaining to childbirth and abortion/stillbirth for female residents is stipulated in accordance with the Labor Standards Law. Fifth, 24 h of continuous rest should be guaranteed at least once per week. Failure to comply with the above criteria may result in fining the training institution or cancelation of the training hospital designation. In addition, a training environment evaluation committee under the Ministry of Health and Welfare should be established to implement a comprehensive resident training plan every 5 years.

Outcome measures

The primary endpoint of this study was a change in the clinical outcomes of patients who underwent emergency abdominal surgery after AITR implementation. In-hospital mortality and length of hospital stay were confirmed as clinical outcomes. The secondary endpoints were changes in the time from ER arrival to surgery before and after AITR implementation in patients who underwent emergency abdominal surgery and the independent effect of AITR on mortality. Moreover, the researchers confirmed the clinical outcomes before and after AITR implementation according to the diagnosis of the patient.

Statistical analyses

Continuous variables, expressed as median and interquartile range, were compared using Student's t-test. Nominal variables were compared using the chi-squared test and Fisher's exact test. In addition, a logistic regression analysis was performed to determine whether AITR was an independent risk factor for mortality. A p value of <0.05 at a 95% confidence interval (CI) was considered statistically significant. All analyses were performed using SPSS ver. 23.0 (IBM Corp., Armonk, NY, USA).

Ethics statement

This study was approved by the Institutional Review Board (IRB) of National Health Insurance Service Ilsan Hospital (IRB approval no. NHIMC 2020-03-060) and adhered to the tenets of the Declaration of Helsinki. The requirement for informed consent was waived by the IRB of NHISIH owing to the retrospective nature of this study. All personal information of the study participants was de-identified.

RESULTS

Patient characteristics

The median age of the 2571 patients was 48.0 years (33.0–60.0) and 1265 (49.2%) were male. The number of patients who underwent emergency abdominal surgery was 474 (18.4%), 480 (18.7%), 501 (19.5%), 597 (23.2%), and 522 (20.3%) in 2015 to 2019, respectively. There were 1453 (56.5%) patients in the pre-AITR period and 1118 (43.5%) patients in the post-AITR period. The most common diagnoses for emergency abdominal surgery were acute appendicitis (82.6%), cholecystitis (7.5%), and major emergencies, such as panperitonitis (9.9%) (Table 1). The initial laboratory tests performed in the ER revealed the following: hemoglobin (Hb) level, 13.9 (12.8–15.2); white blood cell count, 12.07 (9.27–15.05); segmented neutrophil count, 79.0 (70.6–85.3); C-reactive protein (CRP) level, 2.09 (0.50–7.62); blood urea nitrogen (BUN) level, 12.40 (9.80–15.78); creatinine level, 0.76 (0.61–0.90); albumin level, 4.20 (3.90–4.50); and total bilirubin level, 0.97 (0.71–1.34). In addition, the average values of the initial vital signs on arrival were as follows: systolic blood pressure (SBP), 125 (113–139); pulse rate, 81 (71–91); and body temperature, 37.1 (36.7–37.5) (Table 1).

There were two residents per 24-h shift in 69.2%, one in 19.1%, and three in 11.7% of the shifts. The median time from ER arrival to operation was 439.0 (331.0–638.0), and the median length of hospital stay was 4 (4–6). Fifty-two (2.0) patients died (Table 1).

Analysis of the impact of AITR application

The differences between the 1453 and 1118 patients who underwent surgery in the pre- and post-AITR period, respectively, were statistically significant, as were blood urea nitrogen level (p=0.020), total bilirubin level (p<0.001), number of residents per 24-h shift (p=0.004), and type of diagnosis. The median time from ER arrival to surgery in the post-AITR period was longer than that in the pre-AITR period, but the difference was not significant [434.0 (331.0–614.0) vs. 443.0 (333.0–672.0), p=0.230]. In addition, there were no significant differences in the length of hospital stay [4 (4–6) vs. 4 (3–6), p=0.761] and mortality [34 (2.3) vs. 18 (1.6), p=0.192] between the groups (Table 2).

A comparative analysis of the survivors and non-survivors indicated significant differences between the two groups in terms of age, Hb <10 g/dL, neutrophil count >80%, CRP >1.0 mg/dL, BUN >20 mg/dL, creatinine >1.0 mg/dL, albumin <3.0 g/dL, SBP <90 mm Hg, pulse rate >100 bpm, diagnosis, and length of hospital stay (Supplementary Table 1, only online). Based on the significant factors, logistic regression analysis confirmed that age, creatinine >1.0 mg/dL, albumin <3.0 g/dL, and major emergency surgery were independent risk factors (Table 3). However, AITR [odds ratio, 0.660; 95% CI, 0.337–1.292; p=0.225] was not an independent risk factor for mortality (Table 3).

Subgroup analysis by diagnosis

On performing a subgroup analysis of patients who underwent major emergency surgery, there was no statistically significant difference in the time from ER arrival to surgery [413.5 (292.8–558.5) vs. 409.0 (300.0–557.0), p=0.658] between the groups. Similarly, no significant difference was found between the groups in terms of length of hospital stay [13.5 (9.0–23.4) vs. 15.5 (9.0–25.5), p=0.597] and mortality [24 (16.0) vs. 15 (14.4), p=

Table 1. Patient Characteristics (n=2571)

Variables	Value
Age (yr)	48.0 (33.0–60.0)
Sex (male)	1265 (49.2)
Total patients consulted for GS in ER	
2015–2017	3480
2018–2019	2617
Transfer to other hospital	
2015–2017	174 (5.0)
2018–2019	104 (4.0)
Patient who underwent emergency surgery within 24 hr	
Before AITR enforcement	1453 (56.5)
After ATIR enforcement	1118 (43.5)

Year	Total number of resident	Emergency surgery
2015	6	474 (18.4)
2016	6	480 (18.7)
2017	5	501 (19.5)
2018	6	597 (23.2)
2019	8	522 (20.3)

Diagnosis	
Appendicitis	2124 (82.6)
Cholecystitis	193 (7.5)
Major emergency surgery	254 (9.9)
Laboratory test	
Hemoglobin (g/dL)	13.9 (12.8–15.2)
White blood cell count (10^3/uL)	12.07 (9.27–15.05)
Neutrophil count (%)	79.0 (70.6–85.3)
C-reactive protein (mg/dL)	2.09 (0.50–7.62)
Blood urea nitrogen (mg/dL)	12.40 (9.80–15.78)
Creatinine (mg/dL)	0.76 (0.61–0.90)
Albumin (g/dL)	4.20 (3.90–4.50)
Total bilirubin (mg/dL)	0.97 (0.71–1.34)
Vital sign	
Systolic blood pressure (mm Hg)	125 (113–139)
Pulse rate (beats/min)	81 (71–91)
Body temperature (°C)	37.1 (36.7–37.5)
Number of residents on 24-hr shift	
1	492 (19.1)
2	1778 (69.2)
3	302 (11.7)
Time from ER arrival to surgery (min)	439.0 (331.0–638.0)
Length of hospital stay (day)	4 (4–6)
Mortality	52 (2.0)

AITR, Act to Improve Training Conditions and the Status of Medical Residents; ER, emergency room.
Data are presented as interquartile range or n (%).

Table 2. Comparison of Patient Characteristics Before and After AITR Implementation

Characteristics	Pre-AITR (n=1453)	Post-AITR (n=1118)	p value
Age (yr)	46 (33–58)	49 (34–61)	0.001
Sex (male)	715 (49.2)	550 (49.2)	>0.999
Laboratory test			
Hemoglobin <10 (g/dL)	36 (2.4)	36 (3.2)	0.205
Abnormal WBC count (10^3/uL)	1033 (71.3)	758 (68.3)	0.108
Neutrophil count >80 (%)	660 (45.5)	513 (46.3)	0.721
C-reactive protein >1.0 (mg/dL)	872 (61.0)	699 (63.5)	0.187
Blood urea nitrogen >20 (mg/dL)	138 (9.6)	137 (12.5)	0.020
Creatinine >1.0 (mg/dL)	215 (14.9)	163 (14.8)	>0.999
Albumin <3.0 (g/dL)	63 (4.4)	37 (3.9)	0.527
Total bilirubin >2.0 (mg/dL)	113 (7.8)	46 (4.2)	<0.001
Vital sign			
SBP <90 (mm Hg)	27 (1.9)	14 (1.3)	0.224
Pulse rate >100 (bpm)	164 (11.3)	153 (13.7)	0.067
Body temperature >37.8 (°C)	234 (16.1)	190 (17.0)	0.547
Diagnosis			<0.001
Appendicitis	1238 (85.2)	886 (79.2)	
Cholecystitis	65 (4.5)	128 (11.4)	
Major emergency surgeries	150 (10.3)	104 (9.3)	
Number of residents on 24-hr shift			0.004
1	301 (20.7)	191 (17.1)	
2	966 (66.5)	812 (72.6)	
3	186 (7.2)	115 (10.3)	
Time from ER arrival to surgery (min)	434.0 (331.0–614.0)	443.0 (333.0–672.0)	0.230
Length of hospital stay (day)	4 (4–6)	4 (3–6)	0.761
Mortality	34 (2.3)	18 (1.6)	0.192

AITR, Act to Improve Training Conditions and the Status of Medical Residents; ER, emergency room; SBP, systolic blood pressure.
Data are presented as interquartile range or n (%).

Table 3. Risk Factors Associated with Mortality

Variables	OR (95% CI)	p value
Age	1.049 (1.025–1.073)	<0.001
C-reactive protein >1.0 (mg/dL)	2.115 (0.943–4.748)	0.069
Creatinine >1.0 (mg/dL)	2.087 (1.086–4.010)	0.027
Albumin <3.0 (g/dL)	2.396 (1.163–4.940)	0.018
Diagnosis (reference appendicitis)		
Cholecystitis	0.643 (0.082–5.070)	0.675
Major emergency surgery	8.636 (3.884–19.202)	<0.001
AITR implementation	0.660 (0.337–1.292)	0.225

AITR, Act to Improve Training Conditions and the Status of Medical Residents; OR, odds ratio; CI, confidence interval.
Logistic regression analysis included age, hemoglobin <10 g/dL, neutrophil count >80%, C-reactive protein >1.0 mg/dL, blood urea nitrogen >20 mg/dL, creatinine >1.0 mg/dL, albumin <3.0 g/dL, systolic blood pressure <90 mm Hg, pulse rate >100 bpm, and diagnosis.

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0.732] (Table 4).

In the subgroup analysis of patients who underwent minor emergency surgery, we found significant differences in age (p< 0.001), number of residents per 24-h shift (p=0.003), and diagnosis (appendicitis: 95% vs. 87.4%; cholecystitis 5.0% vs. 12.6%; p<0.001) between the groups. However, as in major emergency surgery, there were no significant differences between the groups with respect to the time from ER arrival to surgery [436.0 (332.0–619.0) vs. 446.5 (336.0–685.0) min, p=0.169], length of hospital stay [4 (4–5) vs. 4 (3–5), p<0.316], and mortality [10 (0.8) vs. 3 (0.3), p=0.132] (Table 5).

Table 4. Subgroup Analysis of Patients Who Underwent Major Emergency Surgery

Variables	Pre-AITR (n=150)	Post-AITR (n=104)	p value
Age (yr)	68.0 (51.8–79.0)	68.5 (53.0–79.8)	0.792
Sex (male)	81 (54.0)	50 (48.1)	0.353
Laboratory test			
Hemoglobin <10 (g/dL)	17 (11.3)	21 (20.2)	0.052
Abnormal WBC (10^3/uL)	94 (62.7)	66 (63.5)	>0.999
Neutrophil count >80 (%)	88 (58.7)	60 (57.7)	0.898
C-reactive protein >1.0 (mg/dL)	91 (61.9)	56 (53.8)	0.202
Blood urea nitrogen >20 (mg/dL)	61 (40.7)	45 (43.3)	0.679
Creatinine >1.0 (mg/dL)	60 (40.0)	40 (38.5)	0.805
Albumin <3.0 (g/dL)	45 (30.0)	25 (24.0)	0.296
Total bilirubin >2.0 (mg/dL)	14 (9.3)	4 (3.8)	0.094
Vital sign			
SBP <90 (mm Hg)	12 (8.0)	7 (6.7)	0.705
Pulse rate >100 bpm	40 (15.7)	36 (34.6)	0.174
Body temperature > 37.8 (°C)	22 (14.7)	13 (12.5)	0.622
Number of residents on 24-hr shift			0.511
1	31 (20.7)	16 (15.4)	
2	104 (69.3)	75 (72.1)	
3	15 (10.0)	13 (12.5)	
Diagnosis			0.891
Hollow viscus perforation	102 (68.0)	69 (66.3)	
Abdominal trauma	9 (6.0)	5 (4.8)	
Bowel strangulation	37 (24.7)	28 (26.9)	
Other*	2 (1.3)	2 (1.9)	
Time from ER arrival to surgery (min)	413.5 (292.8–558.5)	409.0 (300.0–557.0)	0.658
Length of hospital stay (day)	13.5 (9.0–23.4)	15.5 (9.0–25.5)	0.597
Mortality	24 (16.0)	15 (14.4)	0.732

AITR, Act to Improve Training Conditions and the Status of Medical Residents; ER, emergency room; SBP, systolic blood pressure.
Data are presented as interquartile range or n (%).
*Foreign body removal, colostomy injury due to dog bite were included in other diagnosis.

DISCUSSION

The effect of AITR on clinical outcomes, such as mortality and hospital stay (the primary endpoint of this study), was not statistically significant. Multivariate analysis also showed that AITR was not an independent risk factor for mortality. In addition, there was no statistically significant difference in the time from ER arrival to surgery after AITR implementation (the secondary endpoint of this study). In subgroup analyses of major and minor emergency surgeries, there were no significant differences in the time from ER arrival to surgery after AITR implementation. In addition, there were no significant differences in length of hospital stay or mortality before and after AITR implementation (Tables 4 and 5). It is also noteworthy that there were no significant differences in the time for ER arrival to surgery and clinical outcomes, even though the on-call staff for each disease group was different. Subgroup analysis for patients with appendicitis and cholecystitis was additionally performed to confirm changes by disease, but there

Table 5. Subgroup Analysis of Patients Who Underwent Minor Emergency Surgery

Variables	Pre-AITR (n=1299)	Post-AITR (n=1005)	p value
Age (yr)	44 (31–55)	48 (33–59.25)	<0.001
Sex (male)	634 (48.7)	500 (49.3)	0.755
Laboratory test			
Hemoglobin <10 (g/dL)	18 (1.4)	15 (1.5)	0.861
Abnormal WBC (10^3/uL)	939 (72.3)	692 (68.9)	0.073
Neutrophil count >80 (%)	572 (44.0)	453 (45.1)	0.618
C-reactive protein >1.0 (mg/dL)	781 (60.9)	643 (64.6)	0.071
Blood urea nitrogen >20 (mg/dL)	77 (6.0)	92 (9.2)	0.003
Creatinine >1.0 (mg/dL)	155 (12.0)	123 (12.4)	0.790
Albumin <3.0 (g/dL)	18 (1.4)	12 (1.4)	>0.999
Total bilirubin >2.0 (mg/dL)	99 (7.7)	42 (4.2)	0.001
Vital sign			
SBP <90 (mm Hg)	15 (0.6)	7 (0.7)	0.256
Pulse rate >100 bpm	124 (9.5)	117 (11.5)	0.114
Body temperature >37.8 (°C)	212 (16.3)	177 (17.5)	0.449
Number of residents on 24-hr shift			0.003
1	270 (20.7)	175 (17.3)	
2	862 (66.2)	737 (72.7)	
3	171 (13.1)	102 (10.1)	
Diagnosis			<0.001
Appendicitis	1238 (95.0)	886 (87.4)	
Cholecystitis	65 (5.0)	128 (12.6)	
Time from ER arrival to surgery (min)	436.0 (332.0–619.0)	446.5 (336.0–685.0)	0.169
Length of hospital stay (day)	4 (4–5)	4 (3–5)	0.316
Mortality	10 (0.8)	3 (0.3)	0.132

AITR, Act to Improve Training Conditions and the Status of Medical Residents; ER, emergency room; SBP, systolic blood pressure.
Data are presented as interquartile range or n (%).

Table 6. Subgroup Analysis according to ER Arrival Time and Operation Start Time

	ER arrival time			Operation start time		
	Day-time (n=1660)	Night-time (n=911)	*p* value	Day-time (n=1201)	Night-time (n=1370)	*p* value
Age (yr)	49 (34–61)	46 (32–57)	<0.001	47 (32–59)	48 (34–60)	0.027
Sex (male)	794 (47.8)	471 (51.7)	0.060	593 (49.4)	672 (49.1)	0.870
Laboratory test						
Hemoglobin <10 (g/dL)	40 (2.4)	31 (3.4)	0.147	26 (2.2)	45 (3.3)	0.084
Abnormal WBC count (10^3/uL)	1097 (66.5)	694 (76.3)	<0.001	876 (73.3)	915 (67.1)	0.001
Neutrophil count >80 (%)	737 (44.7)	436 (48.0)	0.112	565 (48.2)	608 (44.6)	0.176
C-reactive protein >1.0 (mg/dL)	1159 (71.3)	412 (45.5)	<0.001	677 (57.2)	894 (66.4)	<0.001
Blood urea nitrogen >20 (mg/dL)	183 (11.2)	92 (10.2)	0.442	122 (10.3)	153 (11.3)	0.404
Creatinine >1.0 (mg/dL)	260 (15.9)	118 (13.1)	0.056	162 (13.6)	216 (16.0)	0.100
Albumin <3.0 (g/dL)	65 (4.2)	35 (4.2)	0.991	45 (4.0)	55 (4.3)	0.710
Total bilirubin >2.0 (mg/dL)	122 (7.4)	37 (4.1)	0.001	68 (5.7)	91 (6.7)	0.288
Vital sign						
SBP <90 (mm Hg)	23 (1.4)	18 (2.0)	0.253	21 (1.7)	20 (1.5)	0.560
Pulse rate >100 (bpm)	200 (12.0)	117 (12.6)	0.558	157 (13.1)	160 (11.7)	0.284
Body temperature > 37.8 (°C)	273 (16.4)	151 (16.6)	0.933	199 (16.6)	225 (16.4)	0.921
Diagnosis			<0.001			<0.001
Appendicitis	1422 (85.7)	702 (77.1)		959 (79.9)	1165 (85.0)	
Cholecystitis	91 (5.5)	102 (11.2)		135 (11.2)	58 (4.2)	
Major emergency surgery	147 (8.9)	107 (11.7)		107 (8.9)	147 (10.7)	
Number of residents on 24-h shift			0.269			0.888
1	321 (19.3)	171 (18.8)		225 (18.7)	267 (19.5)	
2	1133 (68.3)	645 (70.8)		835 (69.5)	943 (68.8)	
3	206 (12.4)	95 (10.4)		141 (11.7)	160 (11.7)	
AITR	716 (43.0)	402 (44.1)	0.626	551 (45.9)	567 (41.4)	0.022
Surgery at night time	1041 (62.7)	329 (36.1)	<0.001			
Night-time arrival at ER				619 (51.5)	1041 (76.0)	<0.001
Time from ER arrival to surgery (min)	400 (322–515)	599 (379–877)	<0.001	504 (348–841)	411 (322–527)	<0.001
Length of hospital stay (day)	4 (4–6)	4 (4–6)	0.616	4 (4–6)	4 (4–6)	0.021
Mortality	36 (2.2)	16 (1.8)	0.477	19 (1.6)	33 (2.4)	0.137

AITR, Act to Improve Training Conditions and the Status of Medical Residents; ER, emergency room; SBP, systolic blood pressure.
Data are presented as interquartile range or n (%).

were no clinical indicators showing a significant difference due to AITR implementation (Supplementary Table 2 and 3, only online). This suggests that the limitation of working hours of residents has not had a direct factor on delaying the treatment of urgent conditions or decreasing the quality of medical care.

The main contents of the medical resident work limit system implemented by the ACGME in 2003 were designed to limit the average working hours per week to ≤80 h and prohibit continuous work for >24 h, limit on-call duties to every third night, and provide at least a 24-h period off every 7 days.[3,10] In line with this, various working models, such as night floating models and post-call models, were introduced in training institutions to limit the working hours of all residents.[11] After discussing the issue of long working hours for residents in the United Kingdom in 1996, the working hours of medical residents were restricted according to the European Working Time Directive in 2009.[12] This pattern soon expanded across Europe, and although the form and details of work vary among countries, the main aim was to limit the average overtime to 48 h per week, in addition to the detailed regulations proposed by the ACGME.[13,14] There have been several studies in the United States and Europe on the effect of working time restrictions on patient clinical outcomes,[1,11,14-20] and most have reported that limiting working hours for medical residents does not increase patient morbidity and mortality.[18,19]

Similar to training institutions in the United States, in South Korea, individual hospitals prepared for a decrease in the number of doctors due to AITR implementation in various ways.[5,9] In a previous study, a night floating system was introduced, in which daytime and nighttime work did not overlap, and shifts lasted for 12 h. According to the study, the clinical outcomes of patients were not significantly different before and after AITR implementation. However, the response time to ER calls at night

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was significantly reduced.[5] In the case of NHISIH, the same classical night on-call system was operated even after AITR implementation. The classical night on call system inevitably leads to an increase in the intensity of work of the resident's night-shift time after AITR. To investigate the effect of the increased work intensity on patient clinical outcomes, when the ER arrival time was divided into regular time and night-shift time, there was no significant difference in the patients' clinical outcomes according to the ER arrival time (Table 6). Also, there was no difference in the clinical outcomes of the two groups when the surgery start time was divided into regular time and night-shift time for comparative analysis (Table 6).

Although AITR has been implemented, the total number of emergency abdominal surgical cases has not decreased, and the fact that there appears to be no difference in the clinical outcomes of patients could be considered the effect of additional manpower and resource input. In a study on the association between resident working hours and a medical emergency team (MET) that operated continuously for 24 h, there was no significant difference in the clinical outcomes of patients after restriction of resident working hours. However, the MET activation rate was significantly increased and was concentrated on weekends and holidays.[9] This may be attributed to switching the workload of specialists to that of the MET. Our institution also hired a surgical hospitalist. In line with the AITR, a rapid response team was created in 2019, and the number of physician assistant nurses increased from four to five. Therefore, the absence of a difference in the clinical outcomes of patients after the implementation of AITR may have been influenced by the input of additional manpower and resources.

Recently, in the United States and Europe, where restrictions on working hours for residents were implemented nationwide before South Korea, attention has been paid to the results of strict restrictions on working hours for residents that lower their satisfaction with training.[16,17,20] A randomized controlled trial of Flexibility In Duty-hour Requirements for Surgical Trainees (FIRST trial) was conducted in the United States, where the total working hours were unchanged, but detailed continuous working hours restrictions and rest time guarantees were flexibly operated. As a result, there was no significant difference in the clinical outcomes of the patients. However, in the flexible group, forced leave during surgery decreased, while the continuity of the patient's treatment increased. This led to an improvement in overall training satisfaction as in this study and previous domestic studies.[16] Similarly, in this study, there was no significant difference in the clinical outcomes of patients before and after AITR implementation, and additional studies focusing on effective resident education are needed. Meanwhile, however, the medical departments directly affected by the AITR are those dealing with emergency and critically ill patients, including general surgery. In South Korea, these departments face difficulties in recruiting residents every year. Therefore, for training institutions where it is difficult to recruit residents, the AITR could affect clinical outcomes. Therefore, we may need to consider implementing supportive systems in addition to the AITR.

This study had some limitations. First, it was a single-center, retrospective study. Multicenter research is needed because the number of residents and the method of operation of the resident program differ among hospitals. Second, there was no correction for hospital environment. The change in time from ER arrival to surgery may be the result of multiple factors under the influence of the emergency department, anesthesia department, and operating room. Third, the time taken from the arrival at the ER to consultation and the time taken from the request for consultation to the response were not reflected. After the AITR was applied, it was thought to be important to reflect this due to the limitation of the number of medical residents working in all departments, but it could not be confirmed. Finally, the working hours of the residents may not have been accurately observed. In fact, a study has reported that even in the United States, it is common for medical residents to work in hospitals with false-working hours because of an ethical dilemma regarding handoff.[21] Similarly, in this study, there is a possibility that the actual working hours of the residents were not reflected because they were simply divided and compared before and after the implementation of the AITR. Despite these limitations, to the best of our knowledge, this study is meaningful in that it is the first to analyze clinical results after the full implementation of the AITR in South Korea. Additional multicenter prospective studies on this topic are warranted in the future.

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AUTHOR CONTRIBUTIONS

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