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Clinical Impact of a Quality Improvement Program Including Dedicated Emergency Radiology Personnel on Emergency Surgical Management: A Propensity Score-Matching Study

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Objective: To investigate the clinical impact of a quality improvement program including dedicated emergency radiology personnel (QIP-DERP) on the management of emergency surgical patients in the emergency department (ED).
Materials and Methods: This retrospective study identified all adult patients (n = 3667) who underwent preoperative body CT, for which written radiology reports were generated, and who subsequently underwent non-elective surgery between 2007 and 2018 in the ED of a single urban academic tertiary medical institution. The study cohort was divided into periods before and after the initiation of QIP-DERP. We matched the control group patients (i.e., before QIP-DERP) to the QIP-DERP group patients using propensity score (PS), with a 1:2 matching ratio for the main analysis and a 1:1 ratio for sub-analyses separately for daytime (8:00 AM to 5:00 PM on weekdays) and after-hours. The primary outcome was timing of emergency surgery (TES), which was defined as the time from ED arrival to surgical intervention. The secondary outcomes included ED length of stay (LOS) and intensive care unit (ICU) admission rate.
Results: According to the PS-matched analysis, compared with the control group, QIP-DERP significantly decreased the median TES from 16.7 hours (interquartile range, 9.4–27.5 hours) to 11.6 hours (6.6–21.9 hours) ($p < 0.001$) and the ICU admission rate from 33.3% (205/616) to 23.9% (295/1232) ($p < 0.001$). During after-hours, the QIP-DERP significantly reduced median TES from 19.9 hours (12.5–30.1 hours) to 9.6 hours (5.7–19.1 hours) ($p < 0.001$), median ED LOS from 9.1 hours (5.6–16.5 hours) to 6.7 hours (4.9–11.3 hours) ($p < 0.001$), and ICU admission rate from 35.5% (108/304) to 22.0% (67/304) ($p < 0.001$).
Conclusion: QIP-DERP implementation improved the quality of emergency surgical management in the ED by reducing TES, ED LOS, and ICU admission rate, particularly during after-hours.
Keywords: *Quality improvement program; Dedicated emergency radiology; Timing of emergency surgery; Emergency department length of stay; Intensive care unit admission rate*

INTRODUCTION

The implementation of quality improvement programs (QIPs) has been raised as a critical issue in emergency settings [1-3]. To support timely diagnosis and rapid clinical decision-making by clinicians, radiology societies have focused on improving the quality of diagnostic radiology services in the emergency department (ED). The provision of radiology services by dedicated emergency radiology personnel (DERP) is an integral component of this objective. Previous studies have demonstrated reduced turnaround times (TATs) associated with DERP

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implementation [4,5]. Therefore, such systems may shorten the time taken to finalize ED patient dispositions, with positive effects on timely management, medical liability exposure, and diagnostic errors. A recent study showed a decreased ED recall rate by overnight attending radiologists [6]. However, there is still a lot of uncertainty about how, and indeed if, a QIP including DERP (QIP-DERP) would work. Given the associated financial costs in the face of limited resources, the necessity of QIP-DERP implementation remains debated, and its wider application is lacking [7]. Consequently, further evidence of the efficacy of QIP-DERP is warranted.

The timing of emergency surgery (TES) (Fig. 1) is a critical variable affecting the outcomes of patients with acute surgical conditions [8-12]. However, providing high-quality surgical care is challenging owing to the limited resources and unpredictable workloads in the ED. Therefore, surgeons must prioritize the management of patients with severe conditions and high-risk entities. Although patient characteristics and physical condition are critical for determining priority, diagnostic imaging is indispensable for clinical assessments to determine surgical timing. Imaging delays are major contributors to ED or hospital length of stay (LOS) (Fig. 1) [13,14]. We hypothesized that delays in imaging workflows cause delays in surgical treatment, whereas QIP-DERP implementation can expedite the initiation of emergency surgery.

We aimed to investigate the clinical impact of QIP-DERP in a surgical emergency cohort in the ED by comparing outcomes before and after the implementation of the program. The primary outcome was TES. The secondary outcomes were ED LOS, 30-day postoperative in-hospital mortality rate, 30-day post-discharge mortality rate, intensive care unit (ICU) admission rate, and hospital LOS.

MATERIALS AND METHODS

Study Sample

This retrospective study was approved by the Institutional Review Board of the Asan Medical Center (IRB No. 2020-1217), and the requirement for written informed consent was waived. The institution is an urban, tertiary academic hospital with an ED case volume of > 150000 per year. This study included adults who underwent emergency surgery in the ED between January 2007 and December 2018 after preoperative body CT, i.e., thoracic (including CT coronary angiography) or abdominopelvic CT, for which a written radiology report (either signed-off or preliminary) was made available prior to the start of emergency surgery. Emergency surgery was defined as non-elective and non-valvular heart surgery performed within 48 hours after ED admission. Exclusion criteria included having undergone a valvular heart procedure during the study period, because this disease entity was mainly diagnosed using a separate diagnostic pathway (e.g., physician assessment, echocardiography, electrocardiogram-gated cardiac CT, and cardiac MRI). Patients who underwent surgery before written radiology reports were available were excluded given the uncertainty

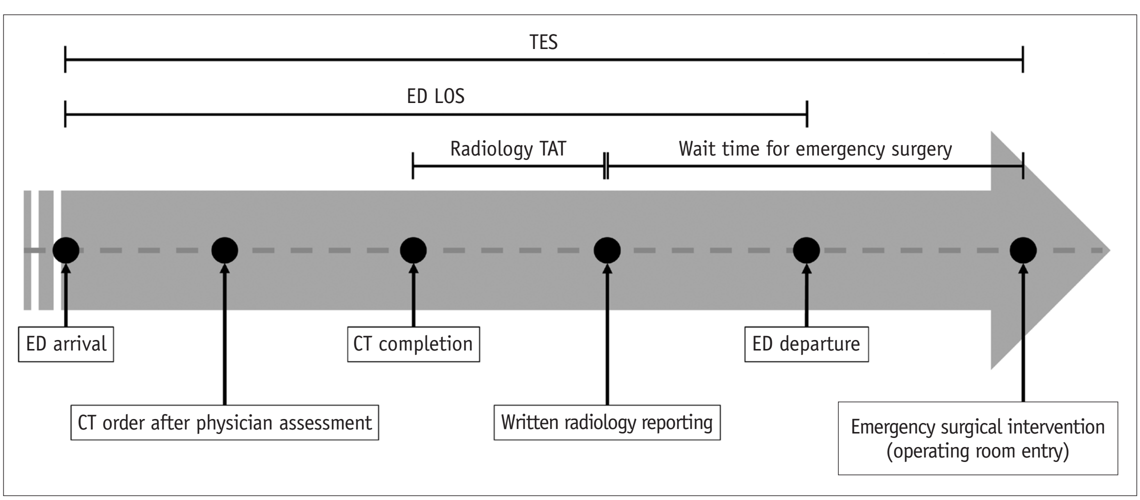

Fig. 1. Schematic time interval of the preoperative ED workflow. The primary time intervals were designated as follows: 1) ED arrival to CT order, 2) CT order to CT completion, 3) CT completion to written radiology reporting (radiology TAT), and 4) radiology reporting to emergency surgical intervention (wait time for emergency surgery). The TES was defined as the interval from ED arrival to emergency surgical intervention (operating room entry). The ED LOS was defined as the interval from ED arrival to ED departure. ED = emergency department, LOS = length of stay, TAT = turnaround time, TES = timing of emergency surgery

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of radiologic intervention and its impact. The TES in those without written radiology reports is typically confounded by additional factors, such as clinical assessment (e.g., disease severity or comorbidity) and surgeons' self-analysis of the imaging findings with or without preliminary verbal communication with radiologists. However, given the long study period, the retrospective study design may have limited the evaluation of certain details in this regard.

Data Collection

The collected data included age, sex, radiology report details, radiologic examination details, radiology service time, timestamps of the preoperative ED workflow, surgical service department, and final surgically confirmed diagnosis. Emergency surgery was categorized into four levels of priority (A to D, descending surgical urgency) for surgery type and indication, based on categories set by previous reports [11,15,16] (see Supplementary Table 1 for priority categories of emergency surgery according to urgency). For timeline analysis, the preoperative ED workflow in surgical emergencies was streamlined according to a previous study [14], and the time intervals were categorized as follows (Fig. 1): 1) ED arrival to CT order, 2) CT order to CT completion, 3) CT completion to written radiology reporting (radiology TAT), and 4) radiology reporting to emergency surgical intervention (waiting time for emergency surgery). Each time interval was recorded and assessed using mean ± standard deviation (SD) and median (interquartile range [IQR, 25th–75th percentile]). Radiology service time was divided into daytime (8:00 AM to 5:00 PM on weekdays) and after-hours (all other times).

QIP-DERP

Our institution implemented QIP-DERP in 2011. After confirming the feasibility of the more common use of preliminary written radiology reports in the ED and minimal discrepancies between preliminary and final reports, the QIP-DERP started to achieve timely provision of written radiology reports (at least preliminary reports before sign-off) for CT scans to the referring physicians before patient disposition finalization or before the start of treatment. To successfully achieve this objective, the program included 1) monitoring the program's performance and sharing results in monthly meetings, 2) regular education of radiology residents, fellows, and staff on the importance of TAT in emergency radiology, and 3) operating a dedicated emergency radiology (DER) section. Specifically, before implementing the QIP-DERP, ED coverage was provided by subspecialized staff radiologists and residents during the daytime and by senior radiology residents with available on-call faculty backup during after-hours. After implementing QIP-DERP, on-site staff radiologists were assigned for an extended period (8:00 AM to 10:00 PM on weekdays and 1:00 PM to 9:00 PM on weekends and holidays), considering the distribution of ED study volume over time. Outside these hours, senior radiology residents alone provided ED coverage with backup on-call faculty radiologists, similar to after-hours before QIP-DERP (see Supplement for the details of the actual application of the QIP and establishment of the DER section).

Study Exposure and Outcome Variables

The exposure in this study was the provision of QIP-DERP. The primary outcome was TES (the interval from ED arrival to emergency surgical intervention) (Fig. 1). The secondary outcomes were ED LOS (interval between ED arrival and departure) (Fig. 1), 30-day postoperative in-hospital mortality rate, 30-day post-discharge mortality rate, ICU admission rate, and hospital LOS.

Statistical Analysis

Descriptive statistics are presented as numbers and percentages or as mean ± SD and median (IQR). To compare the periods before (control) and after QIP-DERP, minimizing confounders, we used propensity score (PS) matching. For PS matching, we selected variables that affected the outcomes and study exposure, based on previous reports [11]. The precision of discrimination and PS calibration were analyzed using the Hosmer–Lemeshow goodness-of-fit test. We used a 1:2 matching ratio for the main analysis and a 1:1 ratio for the sub-analyses separately for daytime (8:00 AM to 5:00 PM on weekdays) and after-hours (all other times). The variables were compared between the groups using the Student's *t* test, Mann–Whitney U-test, chi-square test, or McNemar's test, as appropriate, before and after matching. Standardized mean differences between the groups were calculated to confirm whether the matching was effective, with < 0.1 considered a good balance between groups after matching. After matching, we compared the outcomes between groups using the Wilcoxon signed-rank test, McNemar's test, linear mixed model, or paired *t* test as appropriate. Histogram analysis was used to summarize the distribution of ES according to the TES. The outcome differences were considered statistically significant at a two-sided $p < 0.05$. All statistical analyses were performed using SAS, version 9.4 (SAS Institute).

RESULTS

Study Population Characteristics

During the study period, 4751 patients underwent preoperative body CT and emergency surgery within 48 hours after ED arrival. Of these patients, 98 (2.1%) were excluded from the study because they had undergone valvular heart surgery. Of the remaining 4653 patients, 1253 (26.9%) and 3400 (73.1%) underwent ES before and after QIP-DERP implementation, respectively. In these patients, there was a significant difference before and after QIP-DERP implementation in the proportion of patients whose written radiology reports were available before surgery: 49.2% (616/1253) vs. 89.7% (3051/3400), respectively ($p < 0.001$) (Fig. 2). Of the 4653 patients, 986 (21.2%) were excluded because they had undergone surgery without written radiology reports. The remaining 3667 patients were further analyzed, among whom 616 (control group) and 3051 (QIP-DERP group) underwent emergency surgery before and after QIP-DERP implementation, respectively (Fig. 3). Table 1 summarizes the baseline characteristics of the study population. No significant differences were observed in the variables between matched samples. The present study included a diverse set of emergency operations (general, genitourinary, obstetric, gynecological, vascular, trauma, thoracic, and non-valvular cardiac). The most common surgical category in the matched study population was emergency general surgery (78.5%), followed by obstetric and gynecological surgery (10.9%), and thoracic surgery (5.8%).

TES and ED LOS

Table 2 demonstrates the comparison between the control and QIP-DERP groups for all study participants after PS matching. The overall median radiology TAT significantly decreased from 2.4 hours (IQR, 1.0–9.4 hours) to 0.9 hours (IQR, 0.5–1.7 hours; $p < 0.001$) after the implementation

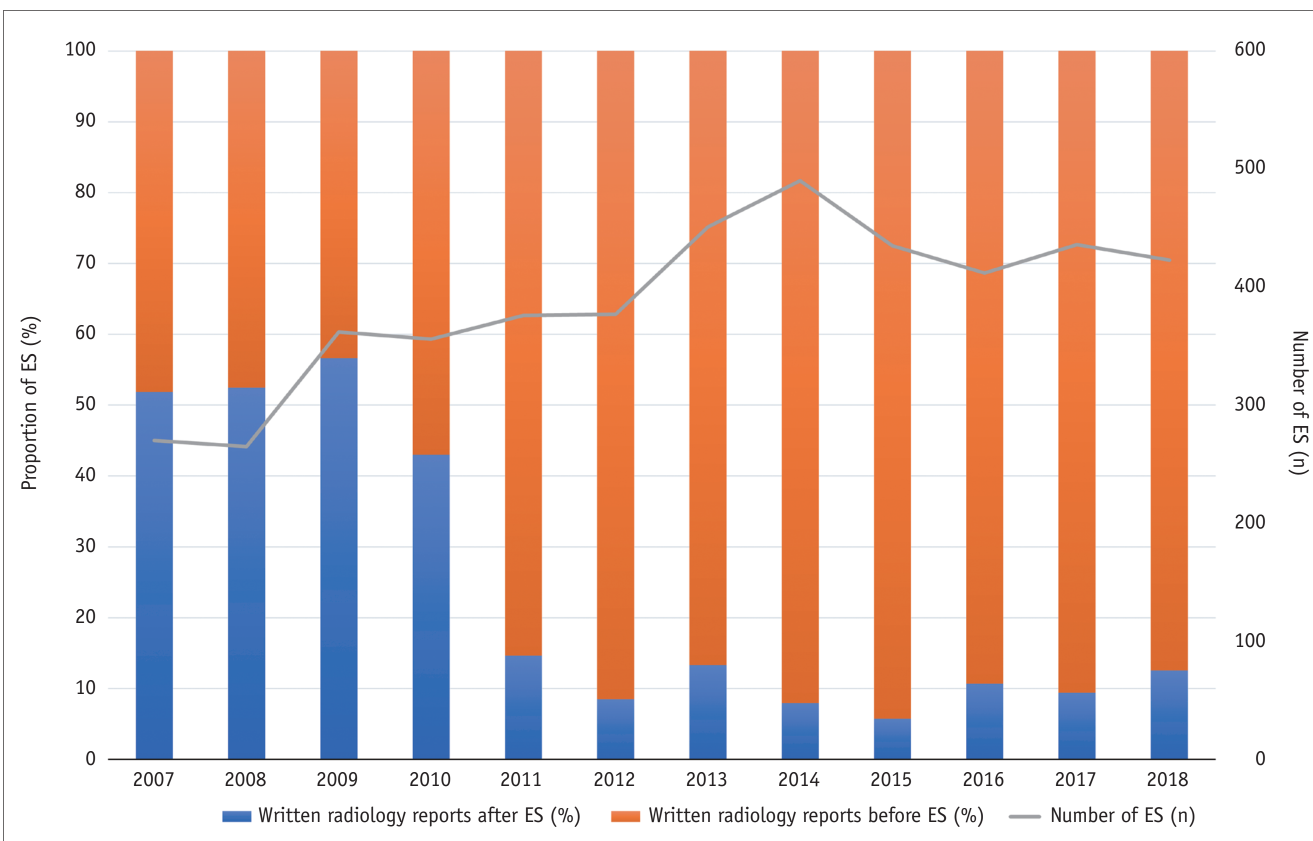

Fig. 2. Proportion of patients whose written radiology reports were available before surgery in surgical emergency cases. The curve shows the number of patients who underwent ES over time. Note that the rate of available written radiology reports is well maintained after implementing the quality improvement program including dedicated emergency radiology personnel despite an increase in the number of ES.
ES = emergency surgery

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of QIP-DERP. Consequently, the overall median TES significantly decreased from 16.7 hours (IQR, 9.4–27.5 hours) to 11.6 hours (IQR, 6.6–21.9 hours; $p < 0.001$) after the implementation of QIP-DERP. However, the difference in the overall median ED LOS did not differ significantly.

Table 3 summarizes the study outcomes according to the radiology service time. In the daytime, although the median TAT decreased significantly after QIP-DERP, the median TES

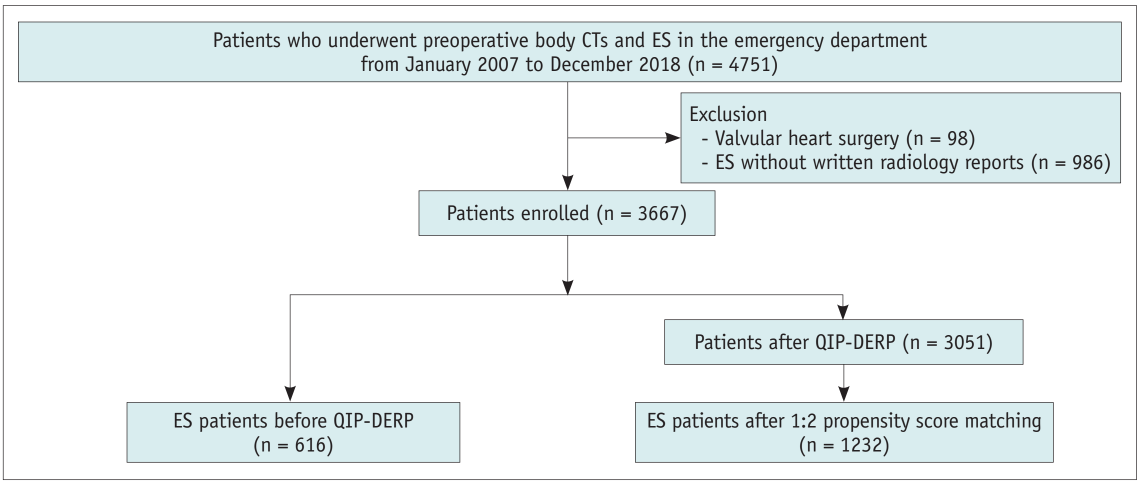

Fig. 3. Flowchart of study patients. ES = emergency surgery, QIP-DERP = quality improvement program including dedicated emergency radiology personnel

Table 1. Patient Characteristics before and after PS Matching

Variables	Before PS Matching				After PS Matching		
	Control (n = 616)	QIP-DERP (n = 3051)	*P*	SMD	Control (n = 616)	QIP-DERP (n = 1232)	SMD
Age, year, mean ± SD	50.1 ± 17.7	53.1 ± 16.2	< 0.001	-0.178	50.1 ± 17.7	50.1 ± 16.6	-0.001
Male sex	323 (52.4)	1613 (52.9)	0.84	0.009	323 (52.4)	663 (53.8)	0.028
Surgical priority category			< 0.001	0.256			0.067
A	142 (23.1)	708 (23.2)			142 (23.1)	264 (21.4)	
B	119 (19.3)	883 (28.9)			119 (19.3)	234 (19.0)	
C	106 (17.2)	496 (16.3)			106 (17.2)	201 (16.3)	
D	249 (40.4)	964 (31.6)			249 (40.4)	533 (43.3)	
Surgical services			< 0.001	0.245			0.062
General surgery	483 (78.4)	2582 (84.6)			483 (78.4)	967 (78.5)	
Obstetric and gynecologic surgery	64 (10.4)	220 (7.2)			64 (10.4)	134 (10.9)	
Thoracic surgery	39 (6.3)	172 (5.6)			39 (6.3)	71 (5.8)	
Genitourinary surgery	13 (2.1)	33 (1.1)			13 (2.1)	24 (1.9)	
Vascular surgery	17 (2.8)	44 (1.4)			17 (2.8)	36 (2.9)	
Time from ED arrival to CT order, hours				0.105			0.036
Mean ± SD	2.2 ± 3.0	1.9 ± 3.1	0.02		2.2 ± 3.0	2.1 ± 3.7	
Median [IQR]	1.5 [0.5–2.6]	1.1 [0.4–2.1]	< 0.001		1.5 [0.5–2.6]	1.1 [0.4–2.2]	
Time from CT order to CT completion, hours				-0.212			-0.050
Mean ± SD	1.1 ± 1.0	1.3 ± 1.2	< 0.001		1.1 ± 1.0	1.1 ± 0.8	
Median [IQR]	0.8 [0.4–1.4]	1.0 [0.6–1.7]	< 0.001		0.8 [0.4–1.4]	0.9 [0.5–1.5]	
Radiology service time			< 0.001	-0.272			0.026
Daytime	350 (56.8)	2130 (69.8)			350 (56.8)	684 (55.5)	
After-hours	266 (43.2)	921 (30.2)			266 (43.2)	548 (44.5)	

Data are number of patients with percentage in parentheses, unless specified otherwise. ED = emergency department, IQR = interquartile range, PS = propensity score, QIP-DERP = quality improvement program including dedicated emergency radiology personnel, SD = standard deviation, SMD = standardized mean difference

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Table 2. Comparison of Outcomes after Propensity Score Matching: Main Analysis

Variables	Control (n = 616)		QIP-DERP (n = 1232)		*P*
	Mean ± SD, Hours	Median (IQR), Hours	Mean ± SD, Hours	Median (IQR), Hours	
Radiology TAT	6.0 ± 7.2	2.4 (1.0–9.4)	1.7 ± 2.8	0.9 (0.5–1.7)	< 0.001*
Wait time for surgery	10.3 ± 9.0	7.0 (3.5–15.2)	10.6 ± 10.4	6.7 (2.9–15.0)	0.37
Timing of emergency surgery	19.5 ± 12.2	16.7 (9.4–27.5)	15.5 ± 11.6	11.6 (6.6–21.9)	< 0.001*
ED length of stay	10.7 ± 7.7	8.2 (5.5–13.6)	9.9 ± 6.9	7.9 (5.2–12.3)	0.16

*$p < 0.05$. ED = emergency department, IQR = interquartile range, QIP-DERP = quality improvement program including dedicated emergency radiology personnel, SD = standard deviation, TAT = turnaround time

Table 3. Comparison of Outcomes after Propensity Score Matching: Sub-Analyses according to Radiology Service Time

Variables	Control		QIP-DERP		*P*
	Mean ± SD, Hours	Median (IQR), Hours	Mean ± SD, Hours	Median (IQR), Hours	
Daytime	n = 212		n = 212		
Radiology TAT	2.4 ± 4.1	1.2 (0.8–1.9)	1.4 ± 2.2	0.8 (0.6–1.4)	< 0.001*
Wait time for surgery	9.9 ± 8.7	6.5 (3.8–14.8)	11.9 ± 10.3	8.1 (4.3–18.8)	0.04*
Timing of emergency surgery	15.6 ± 10.7	11.3 (7.4–24.5)	16.6 ± 11.3	13.4 (7.9–24.6)	0.38
ED length of stay	9.1 ± 6.7	7.0 (5.3–10.2)	11.0 ± 7.9	8.6 (5.9–13.3)	0.003*
After-hours	n = 304		n = 304		
Radiology TAT	8.6 ± 7.7	7.3 (2.0–13.0)	2.0 ± 3.6	0.8 (0.5–1.8)	< 0.001*
Wait time for surgery	10.4 ± 9.0	7.1 (3.4–15.0)	9.1 ± 9.6	5.0 (2.3–13.6)	0.005*
Timing of emergency surgery	22.2 ± 12.4	19.9 (12.5–30.1)	13.8 ± 11.0	9.6 (5.7–19.1)	< 0.001*
ED length of stay	11.8 ± 8.4	9.1 (5.6–16.5)	9.1 ± 6.3	6.7 (4.9–11.3)	< 0.001*

*$p < 0.05$. ED = emergency department, IQR = interquartile range, QIP-DERP = quality improvement program including dedicated emergency radiology personnel, SD = standard deviation, TAT = turnaround time

did not significantly change (11.3 hours [IQR, 7.4–24.5 hours] to 13.4 hours [IQR, 7.9–24.6 hours]; $p = 0.38$), and median ED LOS significantly increased after QIP-DERP compared to the control group (7.0 hours [5.3–10.2 hours] to 8.6 hours [5.9–13.3 hours]; $p = 0.003$). During after-hours, the median TAT and median wait time for surgery significantly decreased after QIP-DERP implementation (7.3 hours [2.0–13.01 hours] to 0.8 hours [0.5–1.8 hours]; $p < 0.001$ and 7.1 hours [3.4–15.0 hours] to 5.0 hours [2.3–13.6 hours]; $p = 0.005$, respectively). Subsequently, the median TES and median ED LOS significantly decreased after QIP-DERP implementation (19.9 hours [12.5–30.1 hours] to 9.6 hours [5.7–19.1 hours]; $p < 0.001$ and 9.1 hours [5.6–16.5 hours] to 6.7 hours [4.9–11.3 hours]; $p < 0.001$, respectively). Figure 4 shows the increased proportion of emergency surgery started in the early time after the implementation of QIP-DERP, and this tendency is pronounced in the more urgent surgery groups (A and B) and during after-hours.

Mortality, ICU Admission Rate, and Hospital LOS

In all patients, the ICU admission rate significantly decreased from 33.3% (205/616) to 23.9% (295/1232) after QIP-DERP implementation ($p < 0.001$) (Table 4). The ICU admission rate significantly decreased during after-hours with QIP-DERP implementation (35.5% [108/304] to 22.0% [67/304]; $p < 0.001$) (Table 4).

DISCUSSION

Few studies have shown favorable clinical outcomes associated with QIP-DERP implementation; however, the consensus on the necessity of this service is growing. Most published reports have focused on radiology TAT. This is because of the complexities in emergency services and confounding factors that mask the actual effect of this service. To our knowledge, this is the first study to investigate the clinical effect of QIP-DERP in an emergency surgery cohort.

The primary finding in our study was that QIP-DERP significantly expedited the start of emergency surgery, especially during after-hours. Although shorter wait times for surgery also contributed to a reduced TES, this contribution was marginal. Our results indicated that the reductions in TES were mainly due to the reduced TATs achieved by QIP-DERP implementation. This result

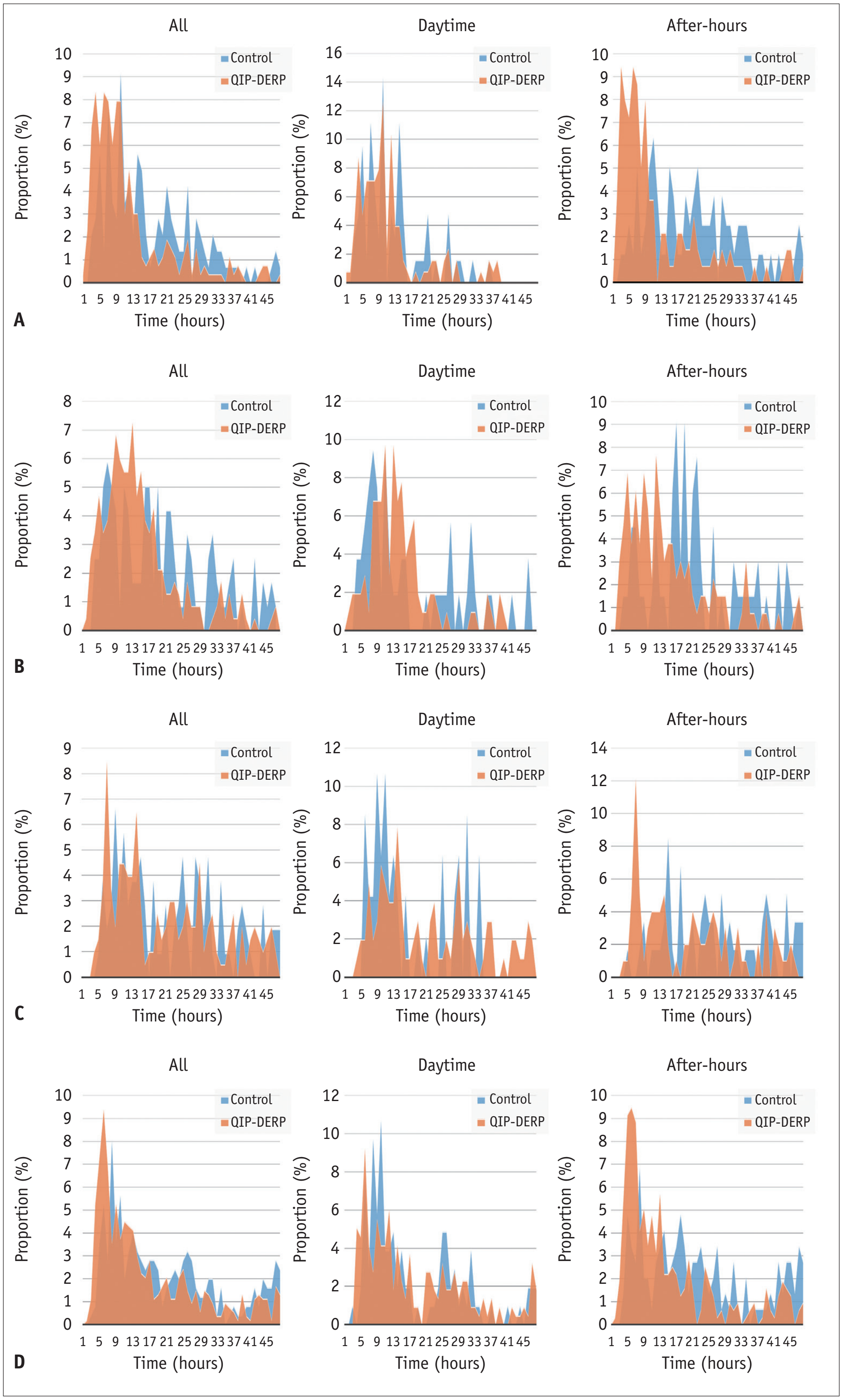

Fig. 4. Proportion of emergency surgery cases according to surgical timing before and after implementing the QIP-DERP.
A-D. Parts **(A)** to **(D)** represents a descending priority of surgical urgency. QIP-DERP = quality improvement program including dedicated emergency radiology personnel

Table 4. Comparison of Mortality, ICU Admission Rate, and Hospitalization Period after Propensity Score Matching

Variables	All			Daytime			After-Hours		
	Control (n = 616)	QIP-DERP (n = 1232)	*P*	Control (n = 212)	QIP-DERP (n = 212)	*P*	Control (n = 304)	QIP-DERP (n = 304)	*P*
30-day postoperative in-hospital mortality rate*	28 (4.5)	37 (3.0)	0.32	7 (3.3)	4 (1.9)	0.37	18 (5.9)	9 (3.0)	0.08
30-day post-discharge mortality rate*	7 (1.1)	17 (1.4)	0.54	2 (0.9)	3 (1.4)	1.00	5 (1.6)	2 (0.7)	0.45
ICU admission rate*	205 (33.3)	295 (23.9)	< 0.001†	65 (30.7)	52 (24.5)	0.16	108 (35.5)	67 (22.0)	< 0.001†
Hospital LOS, days									
Mean ± SD	15.8 ± 34.7	12.8 ± 16.4	0.012	14.2 ± 23.6	13.0 ± 13.7	0.48	15.5 ± 29.1	11.5 ± 15.3	0.03
Median [IQR]	8.0 [4.0–15.0]	8.0 [4.0–15.0]	0.41	8.0 [4.0–14.5]	8.5 [5.0–15.0]	0.41	8.5 [4.0–14.0]	7.0 [3.0–13.0]	0.06

*Data are number of patients with percentages in parentheses, unless specified otherwise, †$p < 0.05$. ICU = intensive care unit, IQR = interquartile range, LOS = length of stay, QIP-DERP = quality improvement program including dedicated emergency radiology personnel, SD = standard deviation

is supported by previous studies that have suggested imaging as a time-limiting factor in the workflow of ED patients. Wang et al. [14] found that CT-related workflow accounted for 29% of the total ED LOS among patients with an acute abdomen. Cournane et al. [13] revealed that radiology imaging delays were associated with a longer LOS for emergency medical admissions. Contrary to our expectation, during the daytime, the median TES did not change, and ED LOS increased after implementing the QIP-DERP, although the median radiology TAT decreased. This could be attributed to systemic delays such as unavailability of surgeons or open operating rooms due to elective surgery during the daytime. Previous studies have shown that systemic factors are the main contributors to delays in emergency surgery [11,17-19]. Our study also showed that during after-hours, QIP-DERP enabled faster departure of patients from the ED to the operating room, which resulted in decreased ED LOS. This result suggests that QIP-DERP implementation can improve patient flow, reduce waiting times for beds, and decrease crowding in the ED. In summary, delayed radiology reporting contributed to surgical delays in the ED. The QIP-DERP implementation is a critical strategy for providing high-quality acute care for patients who require emergency surgery.

Our study demonstrated that QIP-DERP implementation significantly reduced the ICU admission rates. Interestingly, this result appeared during after-hours, which was consistent with the case of expedited surgeries with QIP-DERP implementation in terms of radiology service time. Our results were consistent with those of previous research in the field of surgery regarding the clinical benefits of shorter TES or wait times for surgery [10,11,20-32]. McIsaac et al. [11] demonstrated that delayed surgical intervention was associated with higher in-hospital mortality, longer hospital stay, and higher costs. Loftus et al. [10] showed, with three different representative acute care surgeries, that delayed surgery was associated with prolonged antibiotic administration, longer hospital and ICU LOS, and increased hospital charges. In the case of perforated peptic ulcers and gastrointestinal operations, surgical time has been reported as a critical determinant of survival [27,28]. Meschino et al. [21] found that an increased time from admission to surgery was associated with higher mortality and morbidity rates in emergency general surgical procedures. Compared with these previous studies, it is noteworthy that our study demonstrated the positive clinical impact of time savings in the radiology workflow on surgical emergencies. Moreover,

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our study included various emergency surgical conditions in the ED. Surgical heterogeneity can be an obstacle in reaching clear conclusions regarding the clinical impact of time savings. Our study attempted to address this problem by matching surgical specialties and urgency categories. Nevertheless, this heterogeneity may make it challenging to determine the benefits of QIP-DERP in terms of mortality and hospital LOS in our study. Therefore, further studies with a more detailed control of surgical confounds are warranted to address this issue.

Another key finding of our study was that the overall proportion of patients whose written radiology reports were made available before emergency surgery increased significantly after QIP-DERP implementation. Despite the increased burden of emergency surgery over time, the rate remained constant at approximately 90% after QIP-DERP implementation. Timely radiology reporting rate could be an indicator of emergency radiology service quality. Given the effects of imaging on clinicians' decision making [33,34], this would be crucial in the context of acute care surgery. In our analysis, the timestamps in the timeline analysis reflected the times at which the written radiology reports (at least preliminary reports before sign-off) were delivered. Published studies have reported minimal discrepancies between preliminary and final reports [35-38]. Furthermore, in daily practice, preliminary written reports of critical findings are frequently verbally confirmed before they are signed by ED staff radiologists. Hence, previous reports and clinical practice demonstrated the feasibility of our study design.

This study has several limitations. First, it was a retrospective, single-center, observational study; therefore, the generalizability of its findings is limited. Second, a few confounders and unmeasurable or partially measurable variables (e.g., surgical team accessibility, surgical room occupancy, disease severity, comorbidity, or physiologic status) may weaken the validity of our results. However, each interval in the timeline indirectly reflected the effects of these factors. For example, a lack of operating rooms or higher surgical risks increase the wait time before operating room entry. Nevertheless, further studies should attempt to account for all the possible confounding factors. Third, this study did not assess the quality of radiology reports concerning diagnostic accuracy and errors because of many cases with unavailable preliminary reports, which reflects the limitations of our retrospective study design and long study period. Moreover, our research was intended to inform healthcare administrative personnel and hospital policymakers on implementing QIP-DERP in terms of clinical impact. Fourth, although our priority categorization of emergency surgery referred to the classification schemes proposed in a previous study [11], it required further validation. Finally, the QIP-DERP models vary across institutions. Our DER service has not yet moved to on-site attending coverage for 24 hours a day. Therefore, further large-scale, multicenter studies or randomized trials are needed to accurately determine the effect of QIP-DERP programs on ES duration.

In conclusion, QIP-DERP implementation expedited the start of emergency surgery and shortened ED LOS, leading to a significant reduction in the ICU admission rate, particularly during after-hours. These findings imply that delayed radiology reporting is a modifiable systemic factor contributing to emergency surgery delays, although a combination of multiple systemic factors may cause such delays. Our analysis provides insight into how QIP-DERP implementation can improve the quality of acute care in the context of surgical emergencies in the ED.

Supplement

The Supplement is available with this article at https://doi.org/10.3348/kjr.2022.0278.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Gil-Sun Hong, Choong Wook Lee. Data curation: Gil-Sun Hong, Choong Wook Lee. Formal analysis: Jung Bok Lee. Investigation: Gil-Sun Hong, Bona Kim. Methodology: Gil-Sun Hong, Jung Bok Lee. Project administration: Gil-Sun Hong, Choong Wook Lee. Resources: Gil-Sun Hong, Choong Wook Lee. Supervision: Choong Wook Lee. Validation: Jung Bok Lee. Visualization: Gil-Sun Hong. Writing—original draft: Gil-Sun Hong. Writing—review & editing: Choong Wook Lee, Ju Hee Lee.

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