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Article

Article

The Korean Triage and Acuity Scale: associations with admission, disposition, mortality and length of stay in the emergency department

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Abstract

Objective: The Korean Triage and Acuity Scale (KTAS) was implemented in our emergency department (ED) in May 2016 and is fully integrated into the electronic medical record (EMR) system. Our objective was to determine whether the KTAS is associated with changes in admissions to the hospital, admission disposition, inpatient mortality and length of stay (LOS).
Design: Quasi-experimental, uncontrolled before-and-after study.
Setting: The urban tertiary teaching hospital with 1100 beds and receives approximately annual 90 000 ED visits.
Participants: 122 370 patients who visited the ED during the before-and-the after period.
Interventions: ED staff were educated on the KTAS for 1 month, after which the KTAS evaluation period began. Admission, disposition, mortality and LOS were compared between the 'before' period (1 June 2015 to 30 April 2016) and the 'after' period (1 June 2016 to 30 April 2017).
Main outcome measures: Admissions to the hospital, admission disposition, inpatient mortality and LOS.
Results: A total of 59 220 and 63 150 patients were included in the before-and-after periods of KTAS implementation, respectively. The pattern of admission and disposition changed significantly after implementation of the KTAS. The mean LOS was 343 min (standard deviation [SD] = 432 min) during the before period, which significantly decreased to 289 min (SD = 333 min) after implementation ($P < 0.001$). The total mortality rate was significantly reduced after implementation of the KTAS (213 (0.36%) vs. 179 (0.28%), $P = 0.020$).
Conclusion: Implementation of the KTAS changed admission and disposition patterns and reduced the LOS and mortality in the ED.

Key words: emergency department, triage, mortality, practice variations, emergency care, training/education

Introduction

Triage, the assignment of emergency department (ED) patient severity, is a process that helps predict the intensity and nature of treatment likely to be required [1]. An ideal triage system accurately prioritizes patients based on urgency of need and avoids assigning a triage rating lower or higher than the actual severity. It helps ED personnel to better understand daily operations and streams patients to the appropriate care areas within the ED to mitigate some of the negative effects caused by overcrowding or misclassification [2].

In South Korea, the Korean Triage and Acuity Scale (KTAS) was developed and implemented in 2015 as a tool to identify patients at risk of catastrophic events, including death in the ED. The KTAS consists of a five-level system that classifies patients using a combination of variables, including vital signs and chief complaints. It is a triage tool for a broad range of medical conditions and is used to assess the efficiency of medical intervention and to identify patients who can benefit from effective care in the ED. All EDs in South Korea have implemented this tool to monitor patients and identify those who may deteriorate and might benefit from escalation of care.

In the selected urban tertiary teaching hospital, the KTAS was successfully implemented in May 2015 and is part of the standard nursing protocol in the ED. It is applied to all patients via vital signs recorded in the electronic medical record (EMR) and face-to-face history-taking by ED nurses at the triage section. Our goal was to retrospectively assess whether the KTAS is associated with admission disposition, length of stay (LOS), mortality, and consulted departments (which may also play a part in determining the duration of the hospital stay) in the ED at 1 year after its implementation. Our findings should provide evidence of the usefulness of the KTAS to reinforce its use among healthcare personnel.

Methods

Study design

A quasi-experimental, uncontrolled before-and-after study design was used to evaluate the effects of this education program in ED patients at the selected urban tertiary teaching hospital, which has 1100 beds and receives ~90 000 ED visits annually. This study was approved by the hospital institutional review board, and the requirement for informed consent was waived (No. B-1801-444-004).

Study setting and population

Triage according to the five levels of the KTAS was initiated on 1 June 2016, following the May 2016 educational period. Thus, 1 June 2016 was the start of the 'after' period (until 30 April 2017); the period from 1 June 2015 to 30 April 2016 served as the 'before' period for comparison. Before implementation of KTAS, ED nurses had triaged patients to three levels based on their judgment (Level 1, most severe; Level 2, moderately severe; Level 3, not severe). After implementation of the KTAS, ED nurses triaged patients to five levels (1, 2, 3, 4 and 5).

We used the EMRs of all patients and reviewed the records to determine admission to the hospital, admission disposition, inpatient mortality and LOS in the ED. We excluded all patients who left the ED without any notification to ED staff, were discharged from the ED against medical advice, were dead on arrival, and were referred from an outpatient department.

Introduction to the KTAS

The KTAS was developed through the standardization study of the emergency patient severity classification system of Korea from 2012 to 2015 and was implemented in 2016. It is based on the severity of symptoms, vital signs and chief complaint. The triage levels initially included the terms 'resuscitation, emergency, urgency, less urgency and non-urgency'. However, these terms were changed to '1, 2, 3, 4 and 5' because the meanings of the terms did not exactly match the levels of triage, and these terms seemed to be difficult to understand and apply (Table 1). The new classifications are currently being used in all local and regional EDs in Korea. KTAS education was conducted in this ED during May 2016, and KTAS implementation began in earnest on 1 June 2016 at the ED of the selected hospital.

Categorization of the triage levels in KTAS

KTAS levels were categorized according to emergency symptoms. Related emergency symptoms are combined to provide neurological, cardiovascular, addiction and metabolic disorders, surgical, bleeding, ophthalmic, allergic, pediatric, psychiatric and foreign body related categories. The symptoms corresponding to each KTAS levels were listed, and the classification level is suggested (Supplement file_1). Emergency symptom categories and KTAS levels were analyzed to see if any of the symptoms of the patients could be exclusively applied during the developmental period.

Outcome measures

An ED triage system should allocate ED resources according to patient severity. We hypothesized that changes in disposition, LOS and mortality would reflect the effectiveness of the implementation of the KTAS. Patient demographics and study endpoints, including number of patients, hospitalizations, disposition, transfers and mortality, were collected for analysis. The LOS was defined as the total LOS in the ED and was detailed according to the consulted departments to reduce bias.

Table 1 Definitions of the level of the Korean Triage and acuity scale

Level	Definition
1	Immediate aggressive treatment is needed, and life-threatening (or potentially worse) conditions. Immediate medical examination must be performed.
2	Potential threats to life, limb or body function and a quick intervention is needed. Physician's or nurse's revaluation must be performed within 15 min.
3	Conditions that can lead to serious problems that potentially require emergency intervention. Significant discomforts or influences on physical functions in work or everyday life. Physician's evaluation must be performed within 30 min.
4	Patient's age, condition associated with the possibility of pain or worsening/complications. Patient will be treated and re-verified within 1–2 h. Physician's evaluation must be performed within 60 min.
5	Conditions caused by a chronic problem. Sometimes there is a possibility of exacerbation, or there is a case where it is not. Some of these illnesses or injuries may be delayed or ordered to be performed. Physician's evaluation must be performed within 120 min by a doctor or other hospital.

Methods of measurement

Patient medical records from 1 June 2015 to 30 April 2016 (before period) and 1 June 2016 to 30 April 2017 (after period) were collected by searching the clinical data warehouse, which allows access to all medical records within a center. We searched patient medical charts using a standardized data collection query that included demographics, mortality, disposition, admission status and LOS. Our institution achieved a Stage 7 on the EMR Adoption Model scale (developed in 2010 by the Healthcare Information and Management Systems Society Analytics). At a Stage 7 achievement level, care coordination throughout the hospital is improved by data warehousing, which enables the collection and analysis of care data for performance improvement and clinical decision advancement.

Data analysis

Data were analyzed using Stata statistical software, version 14.2 (Stata Corp LP, College Station, TX). Student's *t*-test was used for comparisons of continuous variables involving independent samples with normal distributions. A nonparametric analysis was performed for continuous data that did not follow a normal distribution. The 95% confidence intervals were also calculated. All significance tests were two-tailed, and a *P*-value of <0.05 was considered statistically significant. The chi-square test was used to compare differences between categorical variables. Continuous data are presented as the means and standard deviations (SD), while categorical data are presented as numbers (percentages). Differences in LOS, disposition and hospitalization rates were compared with the Kruskal–Wallis test, and data are presented as medians and inter-quartile ranges (IQRs).

Results

Differences in the characteristics of patients, consulted departments and disposition results after implementation of the KTAS (Table 2)

A total of 59 220 and 63 150 patients were enrolled before and after implementation of the KTAS (Fig. 1). Patients enrolled after implementation were significantly older (mean difference 1.08 years, 95% CI 0.77 to 1.38, $P < 0.001$) and were more likely to be female than male, but the difference was not significant. The department of internal medicine was the most commonly designated department during both periods, accounting for ~10–11% of patients, and the rate of disposition significantly increased from the before to the after period (6 213 (10.49%) vs. 6 969 (11.04%), $P < 0.001$). The rates of patients referred to the cardiovascular center, respiratory center, and departments of dermatology, neurosurgery, otolaryngology, ophthalmology, and obstetrics and gynecology were significantly reduced during the after period. As a result, the number of patients treated by the department of emergency medicine was significantly increased (37 917 (64.00%) vs. 41 490 (65.70%), $P < 0.001$). The number of patients referred to the department of thoracic surgery was significantly increased (185 (0.31%) vs. 321 (0.51%), $P < 0.001$). The number of patients who were admitted to the general ward or the intensive care unit without surgery was significantly reduced (13 581 (22.94%) vs. 13 599 (21.53%), $P < 0.001$). The number of transfers due to lack of space in the general ward or intensive care unit was also significantly reduced after implementation of the KTAS (444 (0.75%) vs. 285 (0.45%), $P < 0.001$). The number of patients who were hospitalized after surgery was significantly increased (577 (0.97%) vs. 855 (1.34%), $P < 0.001$), and the number of transfers for immediate surgery was also significantly increased (169 (0.29%) vs. 242 (0.38%), 0.004).

Difference in the LOS according to the designated department and the disposition after implementation of KTAS (Table 3)

The mean total LOS was significantly lower after implementation of the KTAS system (mean difference 54 min, 95% CI 49.69–58.31, $P < 0.001$). The LOS of patients who were referred to the cardiovascular center and departments of dental surgery, general surgery, internal medicine, orthopedic surgery, pediatrics and thoracic surgery were significantly reduced after implementation. However, the LOS of patients in the intensive care unit without surgery was significantly increased (mean difference 29 min, 95% CI −0.22 to 58.22, $P = 0.47$). Transfers for immediate surgery were increased after implementation of the KTAS, but the change was not statistically significant. The LOS of other dispositions decreased, and the LOS until discharge from the ED, admission to the general ward, admission to the intensive care unit without surgery, admission to the general ward after surgery, and admission to the intensive care unit after surgery were significantly decreased.

Differences in disposition and LOS according to the triage level after implementation of the KTAS (Table 4)

Patients who were hospitalized to the general ward with or without surgery tended to have a more severe classification before implementation of the KTAS. The total LOS of patients in the intensive care unit without surgery during the before period was significantly shorter than that in the after period. The LOS of Level 1 patients during the before period was significantly longer than that of the after period (419 min (SD = 409 min) vs. 356 min (SD = 356 min), $P = 0.040$).

Patients who were admitted to the intensive care unit had a lower classification level and longer LOS during the before period. This might indicate that less serious patients had severe triage levels, and serious patients were classified at lower triage levels before implementation of the KTAS.

Among discharged patients, serious patients had a longer LOS, but the number of patients was relatively small. However, this finding was not common in transferred patients.

Difference in mortality after implementation of the KTAS (Table 5)

The total mortality rate was significantly reduced after implementation of the KTAS (213 (0.36%) vs. 179 (0.28%), $P = 0.020$). While the mortality rate after cardiopulmonary resuscitation did not significantly change, mortality from other causes was significantly reduced (86 (0.15%) vs. 58 (0.09%), $P = 0.007$). Other causes of mortality included cardiopulmonary diseases, severe trauma, cerebrovascular accident, sepsis, renal diseases and cancer. The monthly variation of mortality showed similar patterns before and after implementation of the KTAS (Supplementary figure). However, the mortality rates in July 2016, August 2016 and January 2017 were prominently reduced.

Discussion

To our knowledge, this is the first study to explore multiple aspects of the impact of the KTAS on an ED. Our study demonstrated that

Table 2 The characteristics of patients, the designated departments and the disposition results before and after implementation of the Korean Triage and Acuity Scale

	01 June 2015–30 April 2016	01 June 2016–30 April 2017	*P*-value
Total, *n* (%)	59 220 (100.00)	63 150 (100.00)	
Age, mean (SD)	41.97 (27.15)	43.05 (27.06)	<0.001
Sex, *n* (%)			
male	28 951 (48.89)	30 548 (48.37)	0.072
female	30 269 (51.11)	32 602 (51.63)	
Consulted department, *n* (%)			
CVC	1 191 (2.01)	1 042 (1.65)	<0.001
DM	77 (0.13)	49 (0.08)	0.004
DR	22 (0.04)	23 (0.04)	0.934
DS	356 (0.60)	339 (0.54)	0.119
EM	37 917 (64.00)	41 490 (65.70)	<0.001
GS	1 956 (3.30)	1 914 (3.03)	0.120
IM	6 213 (10.49)	6 969 (11.04)	<0.001
NP	606 (1.02)	619 (0.98)	0.873
NR	1 299 (2.19)	1 437 (2.28)	0.074
NS	1 905 (3.22)	1 640 (2.60)	<0.001
OG	1 200 (2.03)	1 077 (1.71)	<0.001
OL	1 250 (2.11)	1 199 (1.90)	0.004
OS	472 (0.80)	492 (0.78)	0.599
OT	1 031 (1.74)	1 098 (1.74)	<0.001
PED	2 415 (4.08)	2 560 (4.05)	0.701
PS	158 (0.27)	175 (0.28)	0.762
RC	499 (0.84)	193 (0.31)	<0.001
RH	7 (0.01)	8 (0.01)	0.901
TS	185 (0.31)	321 (0.51)	<0.001
UR	461 (0.78)	505 (0.80)	0.730
Disposition, *n* (%)			
Discharge from ED	43 938 (74.19)	47 623 (75.41)	0.001
Hospitalization to general ward without surgery	12 304 (20.78)	12 410 (19.65)	<0.001
Hospitalization to intensive care unit without surgery	1 277 (2.16)	1 189 (1.88)	<0.001
Hospitalization to general ward after surgery	358 (0.60)	519 (0.82)	<0.001
Transfer due to lack of general ward	284 (0.48)	210 (0.33)	<0.001
Hospitalization to intensive care unit after surgery	219 (0.37)	336 (0.53)	<0.001
Transfer due to patient's need	211 (0.36)	216 (0.34)	0.637
Transfer for immediate surgery	169 (0.29)	242 (0.38)	0.004
Transfer due to lack of intensive care unit	160 (0.27)	75 (0.12)	<0.001
Transfer to nursing hospital	38 (0.06)	86 (0.14)	<0.001
Transfer to lower degree hospital	29 (0.05)	44 (0.07)	0.144
Transfer to specialist	14 (0.02)	11 (0.02)	0.440
Hopeless discharge	8 (0.01)	10 (0.02)	<0.001
Mortality cases	211 (0.36)	179 (0.28)	<0.001

ED, emergency department; SD, standard deviation; CVC, cardiovascular center; DM, dermatology; DR, delivery room; DS, dental surgery; EM, emergency medicine; GS, general surgery; IM, internal medicine; NP, neuropsychology; NR, neurology; NS, neurosurgery; OG, obstetrics and gynecology; OL, otolaryngology; OS, orthopedic surgery; OT, ophthalmology; PED, pediatrics; PS, plastic surgery; RC, respiratory center; RH, rehabilitation; TS, thoracic surgery; UR, urology.

the KTAS led to greater discrimination and effective triage in terms of measured outcomes, such as disposition, hospitalization, LOS and mortality in the ED. We analyzed comprehensive data on patients, with few missing data from the consulted departments, which may also play a part in determining the LOS and disposition.

A validated triage system should not only be consistent with medical needs but should also predict outcomes, such as morbidity, mortality and hospitalization [2–6]. The need for standardized, evidence-based guidelines for triage systems is apparent. Most five-level ED triage systems have been well-developed and validated [2, 3, 7–12]. For example, the Manchester Triage System, which is used in Norway, Sweden, Holland, Germany, Austria, Spain, Slovenia, the UK and Portugal, proved to be a good predictor of length of hospital stay and death in Brazil and Portugal [13].

Because no unified triage system had not been implemented, quality management of ED had not been performed in Korea. However, as Korean healthcare systems become more complex and demand and costs rise, a need exists to use a common-language triage system to efficiently allocate resources and improve patient outcomes and survival [14]. Thus, KTAS was developed over a period of many years and implemented. Implementation of the KTAS reduced the LOS, provided proper classification of patients according to their severity, and significantly decreased in-hospital mortality. The KTAS might be an appropriate triage system in this regard.

The LOS was the only useful indicator that could be used to compare the amount of ED resources consumed and whether patients were well placed in the wards before and after implementation of the KTAS. Statistical comparison of the characteristics of

patients according to triage level was impossible because the ED triage nurses had triaged patients using three levels according to their judgment before implementation of the KTAS. However, we attempted to compare the number and the rate of patients according to triage level and found significant changes between the before-and-after periods. The number of patients admitted to the intensive care unit with a lower triage level and the number of patients admitted to the general ward with a higher triage level were both markedly decreased. The significantly increased number of patients who were admitted to the general ward or the intensive care unit after surgery, the significantly greater number of transfers for immediate surgery, and the significantly reduced number of transfers due to a lack of space in the general ward or intensive care unit might reflect effective changes in ED resource consumption and proper matching of wards to patients according to triage level after implementation of the KTAS.

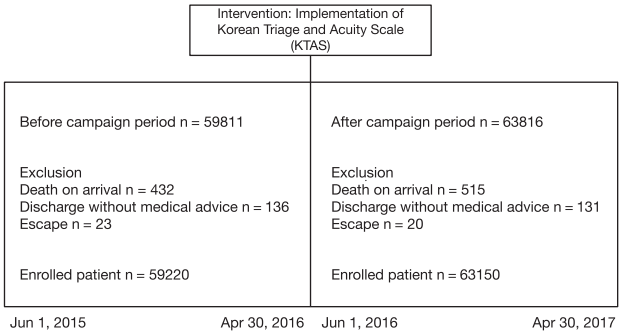

Figure 1 Patients enrolled before and after implementation of the Korean Triage and Acuity Scale.

The LOS was markedly reduced by the KTAS, which reflects proper redistribution and reduced consumption of ED resources [3]. The ratios of patients dispositioned to the department of emergency medicine and the department of internal medicine were significantly increased, but their LOS was decreased. However, the number of

Table 3 The comparison of the length of stay according to the designated departments and the disposition pattern before and after implementation of the Korean Triage and Acuity Scale

Period	01 June 2015–30 April 2016 LOS (min), mean (SD)	01 June 2016–30 April 2017 LOS (min), mean (SD)	*P*-value
Total	343 (432)	289 (333)	<0.001
Consulted department			
CVC	494 (484)	421 (384)	<0.001
DM	208 (213)	182 (109)	0.435
DR	288 (182)	288 (167)	0.996
DS	289 (313)	227 (142)	<0.001
EM	190 (184)	176 (158)	<0.001
GS	505 (446)	440 (362)	<0.001
IM	871 (691)	691 (522)	<0.001
NP	370 (388)	351 (397)	0.391
NR	513 (475)	506 (475)	0.666
NS	593 (565)	538 (517)	0.003
OG	387 (378)	371 (347)	0.295
OL	337 (357)	301 (259)	0.004
OS	807 (679)	506 (485)	<0.001
OT	204 (179)	207 (169)	0.688
PED	710 (512)	451 (289)	<0.001
PS	381 (406)	333 (323)	0.224
RC	767 (607)	633 (444)	0.005
RH	743 (622)	890 (829)	0.690
TS	763 (616)	487(473)	<0.001
UR	503 (542)	444 (373)	0.046
According to disposition			
Discharge from ED	220 (243)	197 (190)	<0.001
Hospitalization to general ward without surgery	767 (635)	615 (484)	<0.001
Hospitalization to intensive care unit without surgery	396 (356)	425 (384)	0.047
Hospitalization to general ward after surgery	487 (401)	420 (393)	0.014
Hospitalization to intensive care unit after surgery	317 (328)	231 (282)	0.001
Transfer due to lack of general ward	408 (641)	396 (338)	0.813
Transfer due to patient's need	496 (497)	470 (562)	0.610
Transfer for immediate surgery	306 (228)	326 (336)	0.499
Transfer due to lack of intensive care unit	352 (456)	276 (178)	0.167
Transfer to nursing hospital	1081 (824)	1021 (970)	0.742
Transfer to second-degree hospital	576 (596)	794 (992)	0.291
Transfer due to absence of specialists	427 (361)	417 (375)	0.944
Hopeless discharge	318 (0.01)	299 (340)	0.906

ED, emergency department; LOS, length of stay; SD, standard deviation; CVC, cardiovascular center; DM, dermatology; DR, delivery room; DS, dental surgery; EM, emergency medicine; GS, general surgery; IM, internal medicine; NP, neuropsychology; NR, neurology; NS, neurosurgery; OG, obstetrics and gynecology; OL, otolaryngology; OS, orthopedic surgery; OT, ophthalmology; PED, pediatrics; PS, plastic surgery; RC, respiratory center; RH, rehabilitation; TS, thoracic surgery; UR, urology.

Table 4 Dispositions and length of stay according to the levels of triage before and after implementation of KTAS

	01 June 2015–30 April 2016 3-Level triage		01 Jun 2016–30 Apr 2017 KTAS 5-Level triage		*P*-value[b]
	N (%)	LOS (min), mean (SD)		LOS (min), mean (SD)	
Hospitalization, *n* (%)	14 158 (100)	343 (432)	14 454 (100)	289 (333)	<0.001
General ward without surgery, *n* (%)	12 304 (86.90)	767 (635)	12 410 (85.86)	615 (484)	<0.001
1	3 547 (23.64)	736 (532)	225 (1.56)	725 (559)	
2	4 760 (33.62)	861 (681)	2 664 (18.34)	619 (536)	
3	4 197 (29.64)	650 (647)	7 247 (50.14)	621 (470)	
4[a]	null	null	2 055 (14.22)	580 (454)	
5[a]	null	null	219 (1.52)	545 (508)	
Intensive care unit without surgery, *n* (%)	1 277 (9.02)	396 (356)	1 189 (8.23)	425 (384)	0.047
1	356 (2.51)	419 (409)	247 (1.71)	356 (356)	
2	380 (2.68)	375 (320)	523 (3.62)	408 (403)	
3	493 (3.48)	394 (341)	360 (2.49)	473 (377)	
4[a]	null	null	51 (0.35)	385 (179)	
5[a]	null	null	8 (0.06)	430 (296)	
General ward after surgery, *n* (%)	358 (2.53)	487 (401)	519 (3.59)	420 (393)	0.014
1	93 (0.62)	266 (231)	5 (0.03)	110 (122)	
2	137 (0.97)	592 (557)	106 (0.73)	307 (334)	
3	128 (0.90)	535 (531)	317 (2.19)	438 (387)	
4[a]	null	null	80 (0.55)	537 (489)	
5[a]	null	null	11 (0.08)	446 (254)	
Intensive care unit after surgery, *n* (%)	219 (1.55)	487 (401)	336 (2.32)	420 (393)	0.001
1	52 (0.44)	460 (376)	56 (0.39)	133 (111)	
2	77 (0.54)	499 (472)	137 (0.95)	175 (287)	
3	80 (0.57)	524 (511)	108 (0.75)	281 (266)	
4[a]	null	null	32 (0.22)	439 (365)	
5[a]	null	null	3 (0.02)	466 (253)	
Discharge from ED, *n* (%)	43 938 (100)	220 (243)	47 623 (100)	197 (190)	<0.001
1	10 759 (24.49)	307	61 (0.13)	542 (520)	
2	20 481 (46.51)	221	3 318 (6.97)	275 (261)	
3	12 698 (28.90)	177	27 659 (58.08)	210 (192)	
4[a]	null	null	13 182 (27.68)	168 (163)	
5[a]	null	null	3 403 (7.15)	116 (122)	
Transfer, *n* (%)	905 (100)	434 (372)	884 (100)	465 (320)	0.059
1	176 (19.45)	307 (288)	56 (6.33)	312 (280)	
2	372 (41.10)	562 (423)	167 (18.89)	328 (291)	
3	457 (39.45)	363 (358)	301 (34.05)	592 (362)	
4[a]	null	null	328 (37.10)	485 (343)	
5[a]	null	null	42 (4.75)	511 (506)	

KTAS, the Korean Triage and Acuity Scale; LOS, length of stay; SD, Standard deviation.
[a]KTAS only.
[b]Results of comparing the mean of length of stay during before-and-after period 905.

Table 5 The mortality pattern before and after implementation of the Korean Triage and Acuity Scale

	01 June 2015–30 April 2016	01 June 2016–30 April 2017	*P*-value
Total patients, *n* (%)	59 220 (100.00)	63 150 (100.00)	
Total mortality, *n* (%)	213 (0.36)	179 (0.28)	0.020
Mortality after cardiopulmonary resuscitation (out-of-hospital cardiac arrest), *n* (%)	111 (0.19)	103 (0.16)	0.315
Mortality after cardiopulmonary resuscitation (In-hospital cardiac arrest), *n* (%)	14 (0.02)	18 (0.03)	0.599
Mortality for other causes, *n* (%)[a]	86 (0.15)	58 (0.09)	0.007

[a]Other causes of mortality: cardiopulmonary diseases, severe traumas, cerebrovascular accident, sepsis, renal diseases and cancer.

patients who were hospitalized in the intensive care unit without surgery was significantly decreased (*n* (%), 1 277 (2.16) vs. 1 189 (1.88), $P < 0.001$), and their LOS was significantly increased (mean (SD), 396 (356) min vs. 425 (384) min, $P = 0.47$). This result might have been due to the increase in the total number of severe patients with or without surgery admitted to the intensive care unit. An added delay of 30 min for critically ill patients in the ED might be intolerable to busy ED staff and nurses and increase consumption of

ED resources. However, the reduction of the total LOS and the specific LOS of other departments may compensate for this delay.

We hypothesized that the mortality rate for other causes might reflect the degree of proper management of critically ill patients. This rate was significantly reduced (86 (0.15%) vs. 58 (0.09%), $P = 0.007$) after implantation of the KTAS. The differences in mortality when stratified by KTAS level are clinically meaningful. A valid triage system is necessary to identify patients who require urgent medical attention, minimize delays and define a department's acuity [15]. The triage performances of ED nurses using the KTAS reduced patient mortality and resulted in better outcomes, satisfying the necessary qualities of a good triage system.

Limitations

This study should be interpreted in the context of the following limitations. First, unmeasured confounding factors were present, such as changes in individual ED medical staff and nurses, which might have influenced the patient management process in the ED. However, to our knowledge, no significant change occurred that might have influenced the study results. Second, this study was conducted at a single medical center within a limited period, which may restrict the general applicability of our findings. We analyzed a large number of patients, without exclusion criteria, which may make our results more generalizable. However, validation studies conducted in different settings and regions would be of interest. In addition, the evaluation of only one year after the implementation of the KTAS might limit the significance and validity analysis, and long-term changes in the ED management and procedures were not addressed.

Conclusions

Implementation of the KTAS changed the admission and disposition patterns and reduced the LOS and mortality in this Korean ED. This study provides evidence of the usefulness of the KTAS and should reinforce its use among healthcare personnel.

Supplementary material

Supplementary material is available at *International Journal for Quality in Health Care* online.

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Authors' contributions

All authors were involved in the conceptualization and designed of this article. All other authors provided critical input to the data analyses and article. All of authors read and approved the final version for submission.

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