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ORIGINAL RESEARCH

Effect of the hospital transfer of STEMI patients through the remote emergency consultation system on the emergency department length of stay and survival at hospital discharge: a single center retrospective cohort study

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Abstract

This study aimed to analyze and determine the effects of emergency department (ED) length of stay (LOS) and survival at hospital discharge (SHD) on patients with ST-segment elevation myocardial infarction (STEMI) treated by the Remote Emergency Consultation System (RECS), a government-led teleconsultation project. This was a retrospective cohort chart review performed at a single center. The study period was from 01 May 2015, to 31 December 2020. The RECS group was set as the intervention group among the total transferred STEMI patients, and the No-RECS group was set as the control group. Ninety-eight patients with STEMI were collectively included in the No-RECS (n = 56) and RECS (n = 42) groups. The median value of ED LOS was 31 (21, 46.5) min in the No-RECS group and 21.5 (13.25, 37.25) min in the RECS group (p = 0.0329). The variables (odds ratio (95% confidence interval (CI)); p-value) predictive of SHD in the patients with STEMI were systolic blood pressure (SBP) (1.09 (1.003, 1.19); p = 0.0413) and total hospital days (2.95 (1.05, 8.26); p = 0.0399). The optimal cut-off points (sensitivity and specificity) of the receiver operating characteristic (ROC) curve of the SBP and total hospital days to predict SHD in the patients with STEMI were (0.742, 1) 105 and (0.753, 1) 3.5, respectively. RECS was associated with a decrease in EDLOS in patients with STEMI, but showed no association with SHD. SBP at the time of the ED visit and total hospital days were positively correlated with SHD.

Keywords

Telemedicine; STEMI; Length of Stay; Survival

1. Introduction

Although emergency medical infrastructure in vulnerable areas, such as rural areas, is continuously expanding, there is a huge gap compared with advisory organizations in large cities [1]. ST-segment elevation myocardial infarction (STEMI) is an emergent disease in which the expression "time is muscle" is used, owing to its pathophysiological characteristics. The recommended door-to-balloon time for reperfusion is 90 min [1–4]. The mortality rate of patients with STEMI during the first six months exceeds 10% [5]. In addition, the 30-day mortality rate after STEMI increases when the reperfusion time increases for various reasons [2]. Therefore, reducing the overall system delay between first medical contact and reperfusion is associated with better patient outcomes, and is recommended by international guidelines [3, 4, 6, 7]. Telemedicine is a valuable tool for improving medical outcomes, and has been proven to be effective in management of patients with STEMI [8–10]. Teleconsultation in South Korea was first piloted as a program called the Remote Emergency Consultation System (RECS), launched on 01 May 2015, under the supervision of the Ministry of Health and Welfare [11–13]. The Korean government expanded the RECS nationwide beginning in July 2016, to improve medical access for emergency patients in vulnerable areas [14].

The Mokpo region, located in Jeollanam-do Province, South Korea, has participated in the RECS project since the pilot project first began in 2015, and has since recorded the highest number of teleconsultations in the country [11]. According to trends in the number of teleconsultations by regional hospitals from 2015 to 2017, the total number of nationwide teleconsultations by the RECS was 1947. Among these, the number of teleconsultations completed by Mokpo Hankook Hospital in the Mokpo area was 1102, accounting for 56.6%, which is the highest in the country [11].

The treatment of emergency patients is often time-sensitive.

It is believed that the final treatment time can be shortened if accurate and objective information is delivered before emergency patients are transferred. We expected that shortening of the final treatment time would increase the survival rate of patients.

In this study, among all patients transferred from other networking-sending local hospitals to Mokpo Hankook Hospital in Mokpo, located in Jeollanam-do Province, Republic of Korea, patients with Stemware categorized into the RECS and No-RECS groups. We subsequently analyzed and determined the effects of teleconsultation on emergency department (ED) length of stay (LOS) and survival at hospital discharge (SHD) in these groups.

2. Methods

2.1 Participants and the study period

The study participants were patients with symptoms and signs of acute coronary syndrome and were classified as having total suspected myocardial infarction. These patients were transferred to the Mokpo Hankook Hospital, a regional emergency medical center, via local networking hospitals including Muan General Hospital, Haenam General Hospital, Jeollanam-do Gangjin Medical Center, Jindo Hankook Hospital, and Wando Daesung Medical Center. These hospitals cover the adjacent islands in Jeollanam-do Province, with a combined population of 1,916,012 people in 2018 (Fig. 1) [15]. These hospitals have participated in the project of "remote cooperation network construction project in vulnerable areas" since 2015 [11].

The five local networking hospitals include the Muan General Hospital, Haenam General Hospital, Jeollanam-do Gangjin Medical Center, Jindo Hankook Hospital, and Daesung Medical Center.

Fig. 1 was developed using Google Maps [16]. The shortest distance to the Mokpo Hankook Hospital from the five networking hospitals was calculated using the Naver map direction service [17].

In this study, the patients were divided into an interventional group and a control group, according to the patient selection process, based on the presence or absence of RECS and percutaneous coronary intervention (PCI) (Fig. 2).

The interventional group comprised patients transferred through the RECS from the five local networking sending hospitals to the Mokpo Hankook Hospital. In these patients, PCI was implemented and used to confirm STEMI on 12-lead Electrocardiography at the referral hospital. The control group comprised patients transferred without using the RECS from the five local networking-sending hospitals to the Mokpo Hankook Hospital. PCI was subsequently performed to confirm STEMI on 12-lead ECG at the referral hospital.

The study period was from 01 May 2015, to 31 December 2020.

2.2 Design, registration, and the study protocol

The RECS project began on a pilot basis in May 2015. Twenty local hospitals participated in the project, centered around the Mokpo Hankook Hospital, which is a regional base hospital. Hospitals that actively participated in the scheme were included as the research target of this study. The Mokpo Hankook Hospital has 550 beds and 80 specialists. It is equipped with an intensive care unit (ICU) of 75 beds and an emergency room of 24 beds. It has 16 emergency medicine specialists and 4 cardiologists. Approximately 35,000 emergency room patients visit the hospital every year, with 10,000 inpatients, 5000 in intensive care units, and approximately 300 STEMI patients annually.

This was a single-center, retrospective cohort chart review. The information of patients who required an inter-hospital transfer was uploaded to the RECS by the doctor of the sending hospital for receipt by the doctor at the referral hospital. The emergency medicine specialists at the Mokpo Hankook Hospital received all patient information via the RECS. At reception, an alarm would go off in the ED of the Mokpo Hankook Hospital, and the doctor on duty electronically would access the RECS to extract the requested patient's information for treatment guidance and inter-hospital transfer. The interventional group was the patient group with STEMI transferred through RECS, and the control group was designated as the No-RECS group. In Korea, it is a legally necessary to check acceptability before transferring patients between hospitals. If it was not contacted through the RECS, it was assumed that all inter-hospital transfer requests were made via the phone. Therefore, among patients with STEMI referred from five hospitals, those managed with a method other than RECS were classified into the No-RECS group.

2.3 Sample size

Appropriate sample sizes were calculated using the G*power 3.1.9.4 program (Statistical Power Analyses for Windows and Mac, Erdfelder, Faul, & Buchner, Dusselfdorf, Nordrhein-Westfalen, Germany). A sample size of at least 82 (41 patients/group) was required for two-sample *t*-test processing, calculated at 80% power (1-beta probability). The Type I error rate was 0.05 and the effect size was 0.63; thus, the actual power was 0.8045777.

2.4 Data collection

We selected the data through retrospective analysis of the electronic medical records of patients visiting the hospital during emergencies. This study was the first to be conducted in Korea, and it was difficult to find similar cases abroad during its initiation. The sample size included all data that could be extracted during the RECS project. The electrocardiogram, which was checked immediately after the patient arrived at the regional emergency medical center, was reviewed by two emergency medicine specialists and was included in the study. The primary data collection was performed through computation. The electrocardiogram STEMI was confirmed through a review by two emergency medicine specialists. All authors reviewed the data coding for one variable. When there was a disagreement, the reviewers discussed the data under the supervision of the corresponding researcher to determine the final variable value. Data from the RECS and No-RECS groups were collected by another researcher and the final statistical analysis was performed by the main author. As such,

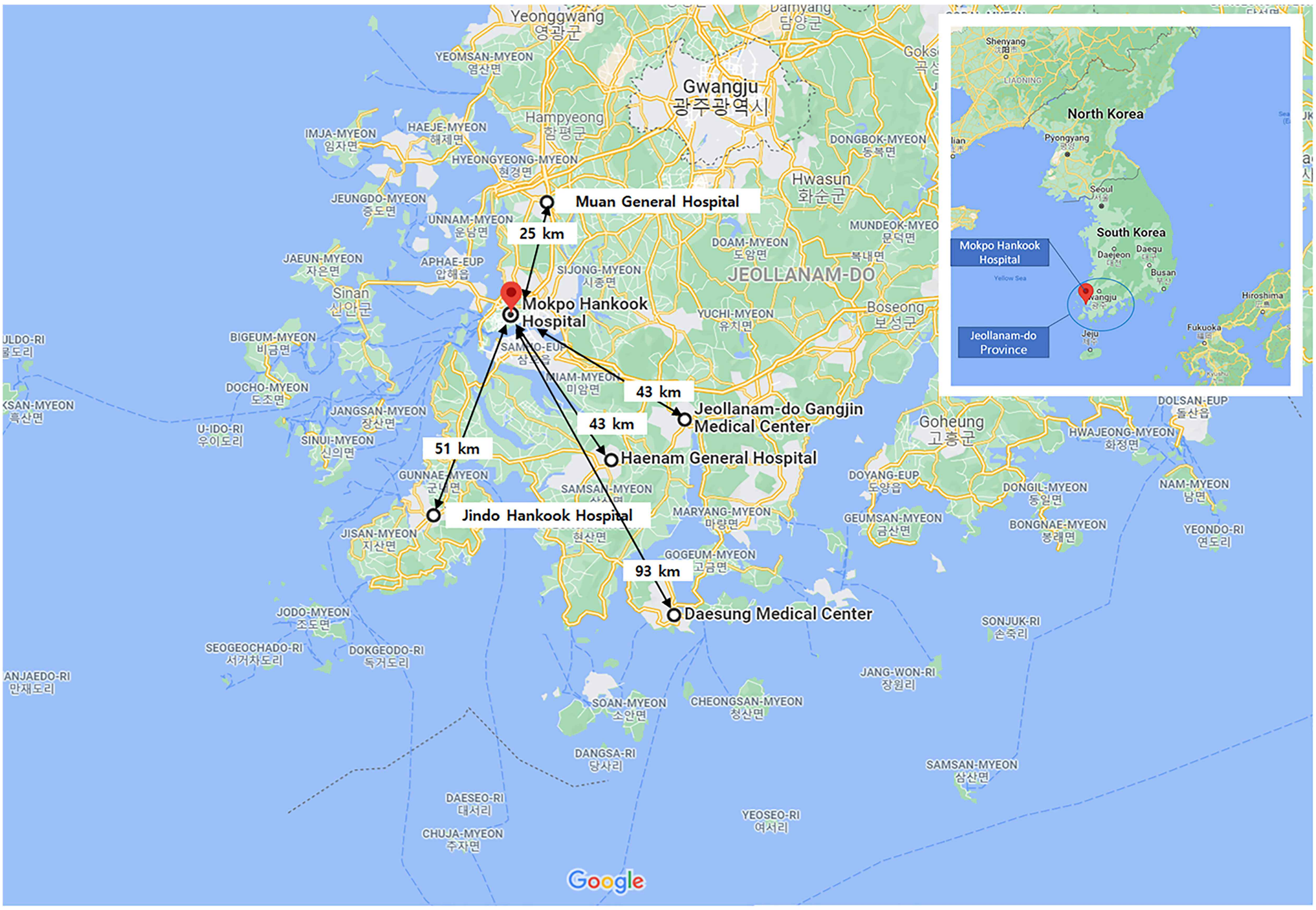

FIGURE 1. Five local networking hospitals and the shortest distance to the Mokpo Hankook Hospital in the RECS covering Jeollanam-do Province. RECS, remote emergency consultation system.

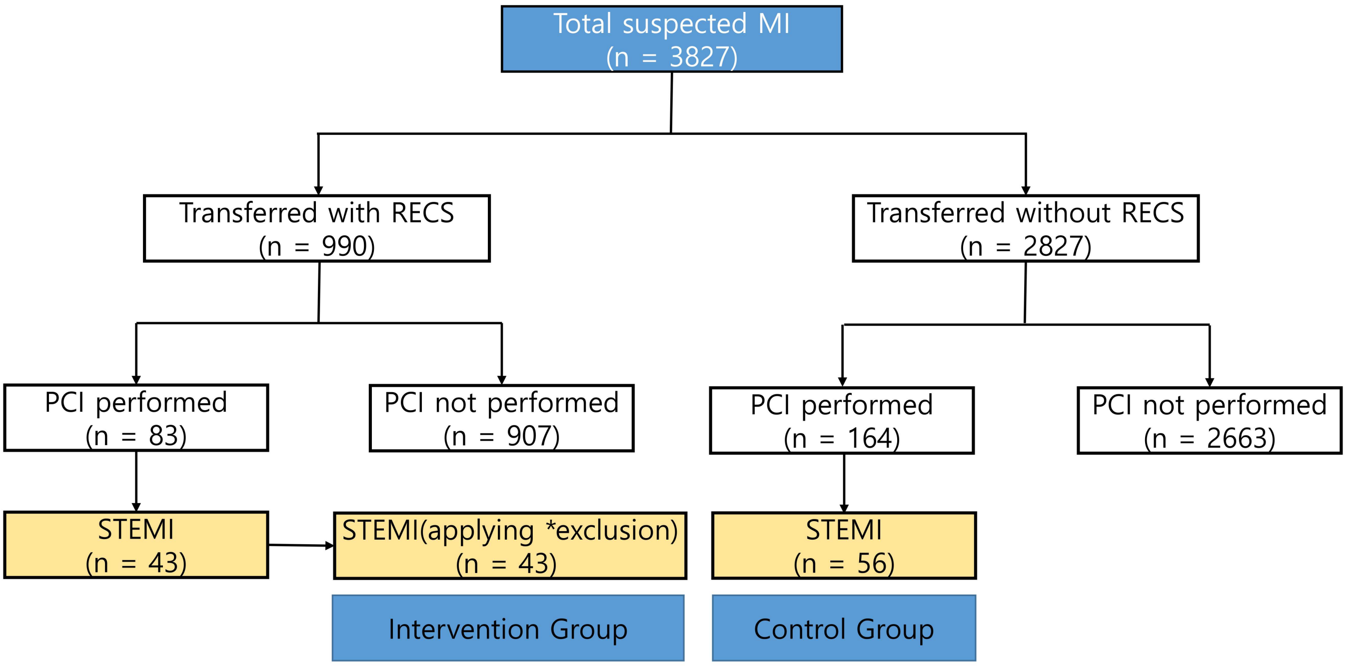

FIGURE 2. Flow diagram of patient selection. MI, myocardial infarction; PCI, percutaneous coronary intervention; RECS, remote emergency consultation system; *one case of STEMI was transferred using the RECS, but PCI was delayed due to refusal to treat the patient, and the patient was eventually excluded. STEMI: ST-segment elevation myocardial infarction.

the researcher in charge of the data of the RECS group was blinded to the results of the No-RECS group, and vice versa.

2.5 Eligibility criteria

2.5.1 Study inclusion criteria

1. Diagnosis of acute coronary syndrome (ACS).
2. Age over 18 years.
3. History of having undergone PCI.
4. STEMI findings on ECG.
5. Transfer to Mokpo Hankook Hospital via the local networking-sending hospitals.

2.5.2 Study exclusion criteria

1. No history of having undergone PCI.
2. Non-STEMI findings on ECG.
3. Delayed PCI due to refusal for treatment by the patient or guardian.

2.5.3 Missing data

Information that could not be extracted, such as that which was not reported or processed in the medical records, was regarded as a missing value and was indicated in the table as "NA" (not applicable or not accountable).

2.6 Variables

2.6.1 Independent variables

Age; time from symptom onset to ED arrival; time from symptom onset to PCI initiation; vital signs upon ED arrival, including systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), respiratory rate (RR), body temperature (BT); LOS in the ward; LOS in the intensive care unit (ICU); total hospital days; gender; categorized time interval from symptom onset to initiation of PCI ($>$720 min or $<$720 min); ED door-to-balloon time (min); categorized time interval from ED visit to initiation of PCI ($<$30 min or $\geq$30 min and $<$60 min or $\geq$60 min); STEMI subtype (anterior or inferior or posterior or lateral or complex (more than two)); ED visiting time of the patient (day duty or night duty); aspirin taken at the referral hospital; clopidogrel taken at the referral hospital; and any underlying diseases, such as hypertension, diabetes mellitus, tuberculosis, asthma, ACS, stroke, chronic renal failure, malignancy, and chronic kidney disease, were set as the independent variables.

2.6.2 Outcome variables

ED LOS and SHD were defined as the outcome variables.

2.7 Analysis

The basic demographic characteristics and clinical outcomes of all eligible patients with STEMI according to the application of RECS (Table 1) and the survival at hospital discharge (SDG) (Table 3) were investigated. Univariate and multivariate binary logistic regression analyses of the variables that predict SDG were conducted (Table 3). Univariate binary logistic regression analysis (UBLRA) was performed on the variables that were significant (Table 2), including the RECS group. Multivariate binary logistic regression analysis (MBLRA) was further performed on the variables that were significant in the UBLRA, including the RECS group, as correcting variables. Significant continuous variables that predict SHD were investigated using the area under the curve (AUC) and optimal cutoff points (sensitivity and specificity) of the ROC curve (Fig. 3).

3. Statistical analysis

Statistical analyses were performed using Rex (http://rexsoft.org/, Version 3.0.3, RexSoft Inc., Seoul, Korea), an Excel-based statistical analysis software. A p-value < 0.05 was considered significant. Data are reported as the mean $\pm$ standard deviation of the parameter values or the median (quartiles, Q1–Q3) of the nonparametric values for continuous variables, and numeric (%) for categorical variables. The p-values were calculated using a two-sample t-test or two-sample Wilcoxon rank-sum test for nonparametric continuous variables and the chi-square test using Yates continuity correction or Fisher's exact test. Categorical variables were two-sided. The Youden index was used to determine the optimal cutoff value [18]. UBLRA and subsequent MBLRA were performed to predict SHD [18]. In the MBLRA, the AUCs of the receiver ROC curves were measured.

4. Results

4.1 Flowsheetfor patient selection

A total of 3872 patients with suspected MI visited the Mokpo Hankook Hospital from 01 May 2015, to 31 December 2020 (Fig. 2). Overall, 98 patients were enrolled, of whom 42 were classified into the RECS group and 56 into the No-RECS group (Fig. 2) (Table 1).

Data are reported as mean $\pm$ standard deviation or median (IQR) for continuous variables, and numbers (%) for categorical variables. p-values were calculated using the two-sided two-sample t-test or two-sided Wilcoxon rank-sum test for continuous variables and the chi-square test with Yates' continuity correction or two-sided Fisher's exact test for categorical variables.

4.2 Basic demographic characteristics and clinical outcomes of the patients with STEM according to the application of the RECS

Of the 98 patients with STEMI, the RR (beats per minute) was 19 (18, 20.25) in the No-RECS group and 18 (16, 19.75) in the RECS group ($p > 0.05$; Table 1). The ED LOS (min) was 31 (21, 46.5) in the No-RECS group and 21.5 (13.25, 37.25) in the RECS group ($p < 0.05$; Table 1).

4.3 Basic demographic characteristics and clinical outcomes of the patients with STEMI according to SHD

Of the 98 patients with STEMI, 93 were classified in the SHD group (SHDG) and 5 in the No-SHDG (Table 2). Among the variables, age (years) was 83 (79, 89) and 69 (57, 80) ($p <$ 0.05); SBP was 80 (80, 90) mmHg and 120 (100, 150) mmHg

TABLE 1. Basic demographic characteristics and clinical outcomes of the patients with STEMI according to the application of the RECS.

Variable	Total (N = 98)	No-RECS group (N = 56)	RECS group (N = 42)	*p*-value
Age (yr)	71 (57, 81)	76 (58, 82)	65 (57, 79)	†0.2834
Symptom onset to ED arrival time (min)	185.5 (120, 419)	210.5 (120, 332)	176.5 (111, 442)	†0.9644
Symptom onset to PCI initiation time (min)	319 (189, 584)	309 (193, 552)	337 (184, 638)	†0.7901
Vital signs on ED arrival				
SBP (mmHg)	121.6 ± 29.7	122.9 ± 28.0	120.1 ± 32.1	‡0.6398
DBP (mmHg)	70 (60, 80)	75 (60, 90)	70 (60, 80)	†0.4051
HR (beat per minute)	77 (64.4, 85.8)	76.5 (63.8, 88.5)	77 (65.5, 82.1)	†0.8877
RR (breaths per minute)	18 (16.4, 20.2)	19 (18.6, 20.2)	18 (16.5, 19.8)	†0.0044
BT (°C)	36.4 (36.3, 36.6)	36.4 (36.2, 36.6)	36.5 (36.3, 36.6)	†0.2421
LOS at ward (day);				
Total (n = 92)				
No RECS group (n = 39)	5 (4, 7)	5 (4, 7)	5 (3.5, 6)	†0.5622
RECS group (n = 53)				
LOS at ICU (day)	1 (1, 2)	1 (1, 2)	2 (1, 2)	†0.0732
Total hospital days (day)	5 (3, 8)	5.5 (3, 8)	5 (3.2, 7)	†0.9986
Gender				
Female	32 (32.7%)	19 (33.9%)	13 (31.0%)	§0.9257
Male	66 (67.4%)	37 (66.0%)	29 (69.1%)	
Categorized time interval from symptom onset to initiation of PCI (min)				
>720 min	22 (22.4%)	13 (23.2%)	9 (21.4%)	§>0.9999
<720 min	76 (77.55%)	43 (76.79%)	33 (78.6%)	
ED door-to-balloon time (min)	81 (63.3, 112.1)	84 (64.5, 107.5)	78.5 (59.2, 116.3)	0.5633
Categorized time interval from ED visit to initiation of PCI (min)				
<30 min	55 (56.1%)	27 (48.2%)	28 (66.7%)	§0.1477
≥30 min and <60 min	25 (25.5%)	18 (32.1%)	7 (16.6%)	
≥60 min	18 (18.4%)	11 (19.6%)	7 (16.7%)	
STEMI subtype				
Anterior	41 (42.7%)	20 (35.7%)	21 (52.5%)	¶0.0618
Inferior	35 (36.5%)	23 (41.1%)	12 (30.0%)	
Posterior	1 (1.0%)	1 (1.8%)	0 (0.0%)	
Lateral	5 (5.2%)	1 (1.8%)	4 (9.5%)	
Complex (more than two)	14 (14.6%)	11 (19.6%)	3 (7.5%)	
ED visiting time of the patient				
Day duty (8 am–6 pm)	53 (54.1%)	32 (57.1%)	21 (50.0%)	§0.6189
Night duty(6 pm–8 am)	45 (45.9%)	24 (42.9%)	21 (50.0%)	
Aspirin taken at the referral hospital				
No	34 (34.7%)	20 (35.7%)	14 (33.3%)	§0.9756
Yes	64 (65.3%)	36 (64.3%)	28 (66.7%)	
Clopidogrel taken at the referral hospital				
No	49 (50.0%)	30 (53.6%)	19 (45.2%)	§0.5403
Yes	49 (50.0%)	26 (46.4%)	23 (54.8%)	
Underlying disease				
HTN				
Not Present	59 (60.2%)	31 (55.4%)	28 (66.7%)	§0.3558
Present	39 (39.8%)	25 (44.6%)	14 (33.3%)	

TABLE 1. Continued.

Variable	Total (N = 98)	No-RECS group (N = 56)	RECS group (N = 42)	*p*-value
DM				
Not Present	77 (78.6%)	45 (80.4%)	32 (76.2%)	§0.8036
Present	21 (21.4%)	11 (19.6%)	10 (23.8%)	
TBC				
Not Present	97 (99.0%)	56 (100%)	41 (97.6%)	¶0.4286
Present	1 (1.0%)	0 (0%)	1 (2.4%)	
Asthma				
Not Present	97 (99.0%)	55 (98.2%)	42 (100%)	¶>0.9999
Present	1 (1.0%)	1 (1.8%)	0 (0.0%)	
ACS				
Not Present	97 (98.98%)	55 (98.21%)	42 (100%)	¶>0.9999
Present	1 (1.0%)	1 (1.8%)	0 (0.0%)	
Stroke				
Not Present	96 (97.96%)	54 (96.43%)	42 (100%)	¶0.5052
Present	2 (2.0%)	2 (3.6%)	0 (0.0%)	
CRF				
Not Present	97 (98.98%)	56 (100%)	41 (97.6%)	¶0.4286
Present	1 (1.0%)	0 (0%)	1 (2.4%)	
Malignancy				
Not Present	97 (98.98%)	55 (98.21%)	42 (100%)	¶>0.9999
Present	1 (1.0%)	1 (1.8%)	0 (0.0%)	
CKD				
Not Present	97 (99.0%)	56 (100%)	41 (97.6%)	¶0.4286
Present	1 (1.0%)	0 (0%)	1 (2.4%)	
ED LOS (min)	26 (17.3, 45.8)	31 (21.5, 46.5)	21.5 (13.3, 37.3)	†0.0329
Survival at hospital discharge				
Not survived	5 (5.1%)	4 (7.1%)	1 (2.4%)	¶0.3882
Survived	93 (94.9%)	52 (92.9%)	41 (97.6%)	

ACS, acute coronary syndrome; BT, body temperature; CKD, chronic kidney disease; CRF, chronic renal failure; DM, diabetes mellitus; DBP, diastolic blood pressure; ED, emergency department; HR, heart rate; HTN, hypertension; ICU, intensive care unit; LOS, length of stay; PCI, percutaneous coronary intervention; RECS, remote emergency consultation system; RR, respiratory rate; SBP, systolic blood pressure; STEMI, ST-elevation myocardial infarction; TBC, tuberculosis; †, Wilcoxon rank-sum test; ‡, two-sample t-test; §, chi-square test with Yates' continuity correction; ¶, Fisher's exact test.

TABLE 2. Basic demographic characteristics and clinical outcomes of the patients with STEMI according to survival at hospital discharge.

Variable	Total (N = 98)	No-SHDG (N = 5)	SHDG (N = 93)	*p*-value
Age (yr)	71 (57, 81)	83 (79, 89)	69 (57, 80)	†0.0210
Symptom onset to ED arrival time (min)	186 (120, 419)	262 (240, 300)	180 (120, 453)	†0.7156
Symptom onset to PCI initiation time (min)	319 (189, 583)	371 (358, 386)	311 (187, 658)	†0.5695
Vital signs upon ED arrival				
SBP (mmHg)	120 (100, 148)	80 (80, 90)	120 (100, 150)	†0.0008
DBP (mmHg)	70 (60, 80)	60 (50, 60)	80 (60, 80)	†0.0028
HR (beat per minute)	77 (64, 86)	80 (68, 85)	76 (64, 86)	†0.4909
RR (breaths per minute)	18 (16, 20)	21 (18, 22)	18 (16, 20)	†0.2071
BT	36.4 (36.3, 36.6)	36.2 (36.2, 36.3)	36.5 (36.3, 36.6)	†0.1279
LOS at ward (day)				
Total (n = 78)				
No-SHDG(n = 0)	5 (4, 7)	NA (NA, NA)	5 (4, 7)	NA
SHDG(n = 78)				
LOS at ICU (day)	1 (1, 2)	1 (1, 2)	1 (1, 2)	†>0.9999
Application of RECS				
Not applied	56 (57.1%)	4 (80.0%)	52 (55.9%)	‡0.3882
Applied	42 (42.9%)	1 (20.0%)	41 (44.1%)	
Total hospital days (day)	5 (3, 8)	1 (1, 2)	6 (4, 8)	†0.0001
Gender				
Female	32 (32.65%)	2 (40.00%)	30 (32.26%)	‡0.6604
Male	66 (67.35%)	3 (60.00%)	63 (67.74%)	
Categorized time interval from symptom onset to initiation of PCI (min)				
>720 min	22 (22.45%)	0 (0.00%)	22 (23.66%)	‡0.5844
<720 min	76 (77.55%)	5 (100%)	71 (76.34%)	
ED door to balloon time (min)	81 (63, 112)	98 (68, 109)	81 (63, 113)	0.5556
Time interval from ED visit to initiation of PCI (min)				
<30 min	55 (56.12%)	3 (60.00%)	52 (55.91%)	‡>0.9999
≥30 min and <60 min	25 (25.51%)	1 (20.00%)	24 (25.81%)	
≥60 min	18 (18.37%)	1 (20.00%)	17 (18.28%)	
STEMI				
Anterior	41 (42.71%)	1 (20.00%)	40 (43.96%)	‡0.0774
Inferior	35 (36.46%)	2 (40.00%)	33 (36.26%)	
Posterior	1 (1.04%)	1 (20.00%)	0 (0.00%)	
Lateral	5 (5.21%)	0 (0%)	5 (5.49%)	
Complex (more than two)	14 (14.58%)	1 (20.00%)	13 (14.29%)	
ED visiting time of the patient				
Day duty (8 am–6 pm)	53 (54.08%)	1 (20.00%)	52 (55.91%)	‡0.1765
Night duty (6 pm–8 am)	45 (45.92%)	4 (80.00%)	41 (44.09%)	
Aspirin taken at the referral hospital				
No	34 (34.69%)	3 (60.00%)	31 (33.33%)	‡0.3377
Yes	64 (65.31%)	2 (40.00%)	62 (66.67%)	
Clopidogrel taken at the referral hospital				
No	49 (50%)	4 (80.00%)	45 (48.39%)	‡0.3619
Yes	49 (50%)	1 (20.00%)	48 (51.61%)	
Underlying disease				

TABLE 2. Continued.

Variable	Total (N = 98)	No-SHDG (N = 5)	SHDG (N = 93)	*p*-value
HTN				
Not Present	59 (60.20%)	1 (20.00%)	58 (62.37%)	‡0.0799
Present	39 (39.80%)	4 (80.00%)	35 (37.63%)	
DM				
Not Present	77 (78.57%)	3 (60.00%)	74 (79.57%)	‡0.2906
Present	21 (21.43%)	2 (40.00%)	19 (20.43%)	
TBC				
Not Present	97 (98.98%)	5 (100%)	92 (98.92%)	‡>0.9999
Present	1 (1.02%)	0 (0.00%)	1 (1.08%)	
Asthma				
Not Present	97 (98.98%)	4 (80.00%)	93 (100%)	‡0.0510
Present	1 (1.02%)	1 (20.00%)	0 (0.00%)	
ACS				
Not Present	97 (98.98%)	5 (100%)	92 (98.92%)	‡>0.9999
Present	1 (1.02%)	0 (0.00%)	1 (1.08%)	
Stroke				
Not Present	96 (97.96%)	4 (80%)	92 (98.92%)	‡0.0999
Present	2 (2.04%)	1 (20.00%)	1 (1.08%)	
CRF				
Not Present	97 (98.98%)	5 (100%)	92 (98.92%)	‡>0.9999
Present	1 (1.02%)	0 (0.00%)	1 (1.08%)	
Malignancy				
Not Present	97 (98.98%)	5 (100%)	92 (98.92%)	‡>0.9999
Present	1 (1.02%)	0 (0.00%)	1 (1.08%)	
CKD				
Not Present	97 (98.98%)	5 (100%)	92 (98.92%)	‡>0.9999
Present	1 (1.02%)	0 (0.00%)	1 (1.08%)	
ED LOS(min)	26 (17, 46)	28 (18, 49)	26 (17, 45)	†0.7332

ACS, acute coronary syndrome; BT, body temperature; CKD, chronic kidney disease; CRF, chronic renal failure; DM, diabetes mellitus; DBP, diastolic blood pressure; ED, emergency department; HR, heart rate; HTN, hypertension; ICU, intensive care unit; LOS, length of stay; No-SHDG, no survival at hospital discharge group; PCI, percutaneous coronary intervention; RECS, remote emergency consultation system; RR, respiratory rate; SBP, systolic blood pressure; SHDG, survival at hospital discharge group; STEMI, ST-elevation myocardial infarction; TBC, tuberculosis; †, Wilcoxon rank-sum test; ‡,Fisher's exact test.

TABLE 3. Univariate and multivariate binary logistic regression analyses of the variables to predict SHD.

Univariate	Estimate	SE	Odds ratio* (95% CI)	p-value	Multivariate (Final model)	Estimate	SE	Odds ratio* (95% CI)	p-value
RECS group	1.15	1.14	3.15 (0.34, 29.31)	0.3125	RECS group	3.18	2.13	24.13 (0.37, 1557.99)	0.1344
Age	−0.09	0.05	0.91 (0.82, 0.99)	0.0489					
SBP	0.06	0.02	1.06 (1.013, 1.11)	0.0129	SBP	0.09	0.04	1.09 (1.003, 1.19)	0.0413
DBP	0.07	0.03	1.07 (1.01, 1.14)	0.0219					
Total hospital days	1.66	0.73	5.27 (1.27, 21.87)	0.022	Total hospital days	1.08	0.53	2.95 (1.05, 8.26)	0.0399

**Wald confidence intervals were calculated; simple regressions with a single covariate were conducted, and coefficients from each regression are summarized; SE, standard error; CI, confidence interval; DBP, diastolic blood pressure; RECS, remote emergency consultation system; SBP, systolic blood pressure; SHD, survival at hospital discharge.*
Final model: Multivariate binary logistic regression analysis of the RECS group adjusted for age, SBP, BP, and total hospital days to predict SHD.

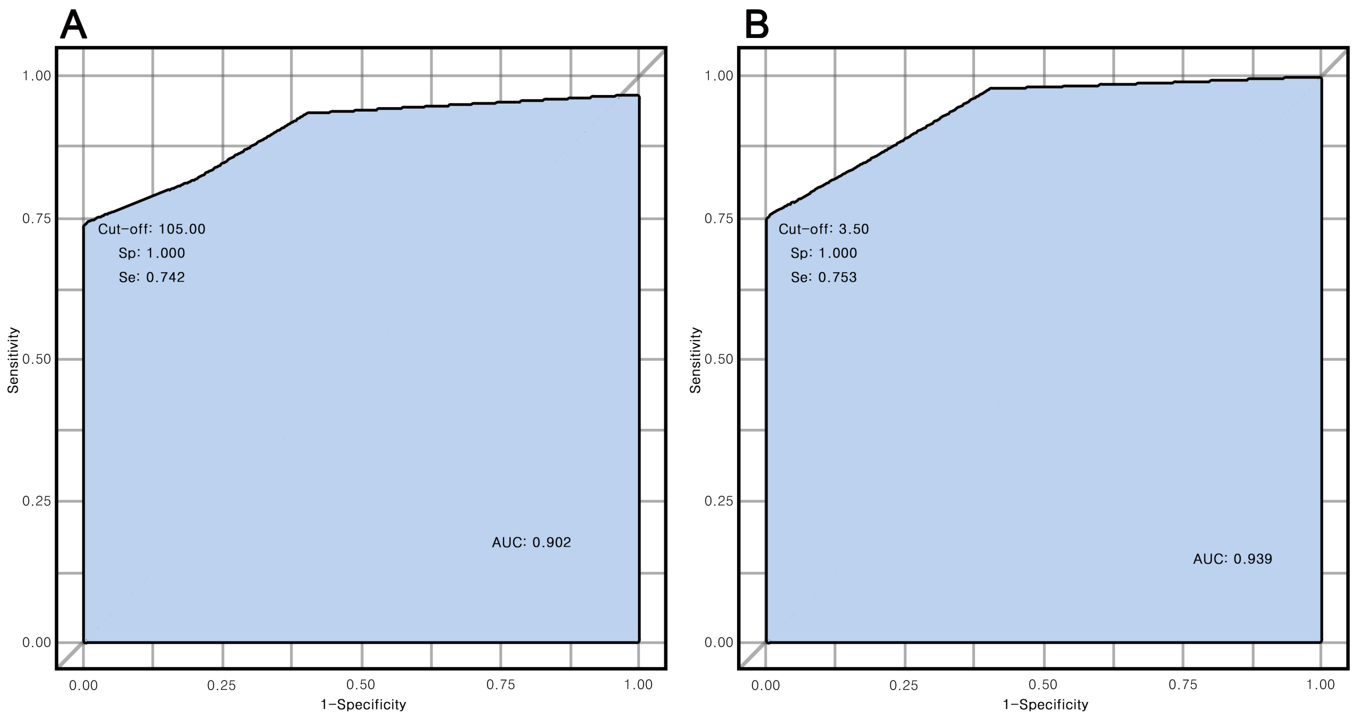

FIGURE 3. The AUC and optimal cut-off points (sensitivity and specificity) of the ROC curve of SBP and total hospital days to predict survival at hospital discharge in the patients with STEMI. A: AUC and optimal cut-off points (sensitivity and specificity) of the ROC curve of SBP to predict SDG in patients with STEMI. B: AUC and optimal cut-off points (sensitivity and specificity) of the ROC curve of total hospital days to predict SDG in patients with STEMI. AUC, area under the curve; ROC, receiver operating characteristic; SBP, systolic blood pressure; SDG, survival at hospital discharge; Se, sensitivity; Sp, specificity.

($p = 0.0008$); DBP was 60 (50, 60) and 80 (60, 80) ($p = 0.0028$); and the total hospital stay was 1 (1, 2) and 6 (4, 8) ($p = 0.0001$) in the No-SHDG and SHDG, respectively (Table 2).

Data are reported as medians (IQR) for continuous variables, and numbers (%) for categorical variables. p-values were calculated using two-sided Wilcoxon rank-sum test for continuous variables and two-sided Fisher's exact test for categorical variables.

4.4 Univariate and multivariate binary logistic regression analyses of variables to predict SHD

SHD, age, SBP, DBP, and total hospital days were significant variables in the UBLRA (Table 3); ($p < 0.05$). The prediction of SHD was implemented in the MBLRA using the RECS group as a fixed variable and correcting for the above four variables. The odds ratios (95% CI, p-value) of the RECS group, SBP, and total hospital days were (RECS group; 24.13 (0.37, 1557.99), p = 0.1344), (SBP; 1.09 (1.003, 1.19), p =

0.0413), and (total hospital days; 2.95 (1.05, 8.26), $p = 0.0399$), respectively (Table 3).

4.5 AUC and optimal cutoff points (sensitivity and specificity) of the ROC curve for SBP and total hospital days to predict SHD in patients with STEMI

The AUC and optimal cutoff points (sensitivity and specificity) of the ROC curve to predict SHD for SBP were 0.902 and 105 (0.742, 1) and for total hospital days were 0.939 and 3.5(0.753, 1), respectively in the patients with STEMI (Fig. 3).

5. Discussion

In Korea's emergency medical system, the scope of paramedic work at the pre-hospital stage is expanding. As of 2022, the duties of paramedics include checking the electrocardiogram, obtaining the electrocardiogram results from the emergency guidance doctor, and selecting a destination hospital for patient transport according to the results. However, the scope of paramedics' work was limited during the study period. According to the National Emergency Management Agency's standard guidelines for on-site first aid for emergency paramedics, paramedics are required to transport patients suspected of having acute myocardial infarction to the local hospital immediately, and subsequently, the patients need to be transferred to the base hospital. Therefore, local hospitals in which final treatment for myocardial infarction is impossible should transfer patients to base hospitals after initial diagnosis and treatment.

Two hypotheses are proposed in this study. First, we hypothesized that the use of RECS would significantly reduce ED LOS in patients with STEMI. Second, we proposed that the use of RECS would improve SHD in patients with STEMI. We confirmed that the use of RECS was related to reduce ED LOS in patients with STEMI. However, no evidence showed that the presence or absence of RECS itself improved SHD. In addition, SBP and the total hospital days of patients at the time of their ED visit were positively correlated with SHD. The cut-off values for SBP and total hospital days were 135 and 3.5, respectively.

The median age of the participants was 70.5 years, which was consistent with the demographic characteristics of previous studies, which reported the highest incidence of STEMI in the 50–90 year age group [19].

Although the use of RECS was associated with a reduction in ED LOS in patients with STEMI, the median ED door-to-balloon time for the investigated patients was 81 min. No significant differences were observed between the No-RECS group at 84 min and the RECS group at 78.5 min. Since 2016, the door-to-balloon time of primary PCI in Korea has been 62 min, and the Mokpo Hankook Hospital has implemented a relatively long door-to-balloon time [20].

RECS management was not found to have a significant predictive value for SHD in the UBLRA. However, the UBLRA revealed a more than three-fold odd ratio (OR). Subsequently, in the RECS group adjusted for age, SBP, DBP, and total hospital days, the p-value decreased significantly in the MBLRA more than 24 fold compared to the OR in the UBLRA. These results show a tendency for an overall positive correlation between RECS implementation and SHD prediction. A recent study showed that telehealth increased the fatality rate by 13.7% in the non-treated group, compared to 4.1% in an administered group of patients with STEMI during the COVID-19 pandemic [21]. Another study reported that pre-hospital triage with a trans-telephonic electrocardiogram and direct referrals for catheter therapy were independent predictors for improved in-hospital survival and mortality in patients with STEMI [22].

A previous study indicated that an extended interval between symptom onset and hospitalization was the most important independent predictor of an increased risk of in-hospital mortality[21].However, in this study, the symptom onset to ED arrival time, symptom onset to PCI initiation time, categorized time interval from symptom onset to initiation of PCI ($\geq$720 or $<$720), and the time interval from the ED visit to the initiation of PCI ($<$30 min, $\geq$30 min,$<$60 min, and $\geq$60 min) did not differ between the No-SHDG and SHDG.

In this study, we detected no significant difference in the presence or absence of SHD according to STEMI subtype classification. However, according to the Latin America Telemedicine Infarct Network (LATIN) data, the STEMI localization model provides promising results for anterior and inferior wall STEMI [22].

During the RECS project, there was no emphasis on using RECS to prepare treatment for patients with STEMI in advance. In general, even if the base hospital emergency doctors receive requests from STEMI patients over the phone, they would contact the cardiology department only after the patient had arrived at the base hospital, subsequently check the ECG, and prepare for cardiovascular angiography. This can be attributed to two factors. First, trust in the referring doctor may have been insufficient. For example, even if STEMI is delivered over the phone, there are a few cases in which ST elevation is not observed on ECG. In other words, there are cases in which ST elevation is misdiagnosed as STEMI. These problems inevitably weaken the trust between referring and receiving doctors. Therefore, the base hospital doctors responded after checking the ECG to reduce unnecessary responses. Second, there is the psychological element of the doctor. We believe that all doctors are aware that STEMI is a time-sensitive disease; however, the psychological tension between checking the ECG directly and receiving a call only over the phone is bound to be different. Therefore, even before the arrival of the patient, it is thought that the doctor in the emergency room of the base hospital who confirmed the ECG is strained and will attempt faster treatment.

Although this study was limited to STEMI in a single center in rural areas, our results strongly suggest that the application of RECS can shorten the final treatment time for time-sensitive diseases. Using RECS, even in severe trauma and cerebrovascular disease, image information such as computed tomography and magnetic resonance imaging can be transmitted in advance so that the final treatment can be prepared first. In addition, it is expected that the final treatment time can be shortened if a medical information delivery system such as RECS is applied to time-sensitive and seriously-ill patients in urban and rural areas.

We anticipate that when a critically-ill, time-sensitive patient sensitive is transported, the final treatment time can be shortened by providing appropriate medical information in advance, and ultimately, the survival rate can be improved. Although the ED LOS decreased in this study, the SHD did not show a significant difference. Ultimately, reducing the ED LOS and shortening the final treatment time will reduce mortality.

6. Limitations and Strengths

This study was limited by selection bias as it was conducted at a single center in a specific region and was retrospective in design. In addition, as the period from January to December 2020 coincided with the COVID-19 pandemic, the possibility of STEMI due to a thromboembolic event caused by COVID-19 cannot be excluded. Further, the analysis of factors affecting the period until PCI initiation, even after patients left the ED, was not included in this study, except for cases in which the balloon time due to the PCI procedure had increased. Nevertheless, the results of this study are strongly representative, as Mokpo Hankook Hospital performs more than 50% of the total number of RECS consultations in the country [11]. In addition, this study is the first to demonstrate the effectiveness of RECS for patients with STEMI in Korea. Future multicenter prospective studies should be performed to investigate whether reducing ED LOS using RECS in patients with STEMI will contribute to resolving ED congestion and SHD.

7. Conclusions

In conclusion, RECS significantly reduced ED LOS in patients with STEMI. SBP and total hospital days were predictors of SHD.A prospective randomized controlled study is needed to accurately evaluate the contribution of RECS on ED crowding and to improve the survival rate in patients with STEMI.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

JHK, JKN—designed the research study. JHK, JL—performed the research. HS—analyzed the data. JHK and HS wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was supported by the National Medical Center and approved by the Institutional Review Board of the National Medical Center in South Korea (NMC-2021-08-101/Approval date 12 August 2021). All participants provided consent to participate in the study. All methods were performed according to the relevant guidelines and regulations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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