Factors for modifying the termination of resuscitation rule in out-of-hospital cardiac arrest

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Background False positive rate (FPR) of the current basic life support (BLS) termination of resuscitation (TOR) rule in out-of-hospital cardiac arrest (OHCA) patients (not witnessed; no return of spontaneous circulation prior to transport; and no shocks were delivered) has been ethically challenging. We validated the current BLS TOR rule with using nationwide Korean Cardiac Arrest Research Consortium (KoCARC) registry and identified the factors for modifying the rules.

Methods This prospective, multicenter, registry-based study was performed using the nontraumatic OHCA registry data between October 2015 and June 2017. Independent factors associated with poor neurologic outcome were identified to propose new KoCARC TOR rules by using multivariable analysis. The diagnostic performances of the TOR rules were calculated respectively.

Results Among 4,360 OHCA patients, 2,801 (64.2%) satisfied all 3 criteria of the BLS TOR rule. The FPR and positive predictive value of the BLS TOR rule were 5.9% and 99.3%. Asystole as initial rhythm and age > 60 years were found as new factors for modifying the TOR rule. New KoCARC TOR rules, combination of asystole and age > 60 years with current TOR rule, showed lower FPR (0.3%-2.1%) and higher positive predictive value (99.7%-99.9%) for predicting poor neurologic outcome at discharge.

Conclusions In this recent nationwide cohort, the current BLS TOR rule showed high FPR (5.9%) for predicting poor neurologic outcome. We anticipate that our new KoCARC TOR rules, application of 2 new factors (asystole as initial rhythm and age > 60 years) with BLS TOR rule, could reduce unwarranted death. (Am Heart J 2019;213:73-80.)

The recent guidelines for health care providers about cardiopulmonary resuscitation (CPR) decision making for out-of-hospital cardiac arrest (OHCA) patients suggested the basic life support (BLS) termination of resuscitation (TOR) rule that has 3 criteria, all of which must be present before terminating resuscitative efforts: (1) arrest was not witnessed by emergency medical services (EMS) personnel or first responder; (2) no return of spontaneous circulation (ROSC) was observed prior to transport; and (3) no shocks were delivered.[1] TOR rule was developed for identifying the patients who would not survive after transport to hospital to reduce futile transport. However, recent studies, where prehospital termination were legally prohibited, showed much higher false positive rate (FPR) and lower positive predictive value (PPV) than those of other studies conducted in North America.[2-5] In addition, some councils have challenged the TOR rules and argue that applying the TOR rules leads to an unexpected survival of 3.6% and 9%, respectively.[6-8] Furthermore, extracorporeal membrane oxygenation (ECMO) CPR in emergency departments (ED) has been suggested as a potential rescue therapy in refractory OHCA patients with the suspected cardiogenic etiology of arrest. These results may suggest the possibility of

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missed potential survivors and that nontraumatic OHCA patients should be transferred to the hospital.

This study was to assess diagnostic performance of the BLS TOR rule using a nationwide registry of OHCA patients and to identify the factors for modifying the TOR rule that has the lowest FPR and highest PPV value for predicting poor neurologic outcome at hospital discharge.

Materials and methods

Study design and setting

This multicenter, prospective, observational, registry-based study was performed using the Korean Cardiac Arrest Research Consortium (KoCARC) data between October 2015 and June 2017. The KoCARC is a multicenter, nationwide collaborative research network of 62 participating institutions developed to comprehend various researches conducted in the field of OHCA and to strengthen the cooperative effort in conducting studies.[9] The KoCARC registry enrolled consecutive nontraumatic OHCA patients transported to the participating ED with resuscitation efforts. The registry excluded OHCA patients with terminal illness documented by medical record, under hospice care, with pregnancy, and with a predocumented "Do Not Resuscitate" card. OHCA of definite noncardiac etiology, including trauma, drowning, poisoning, burn, asphyxia, or hanging, were also excluded. Data are collected via a standardized registry form and are entered into Web-based electronic database registry according to Utstein style by collecting from EMS records and hospital medical records starting from October 2015. The quality management committee quality assurance plan includes checking completeness and consistency of mandatory fields, as well as checking for inbuilt validation rules that cross-check data fields. In addition, they give feedback to each research coordinators and investigators of the result of quality management process through every quarterly meeting. KoCARC data collecting protocol was reviewed and approved by each participating hospital Institutional Review Board. The KoCARC registry was registered under clinicaltrials.gov as protocol NCT03222999.

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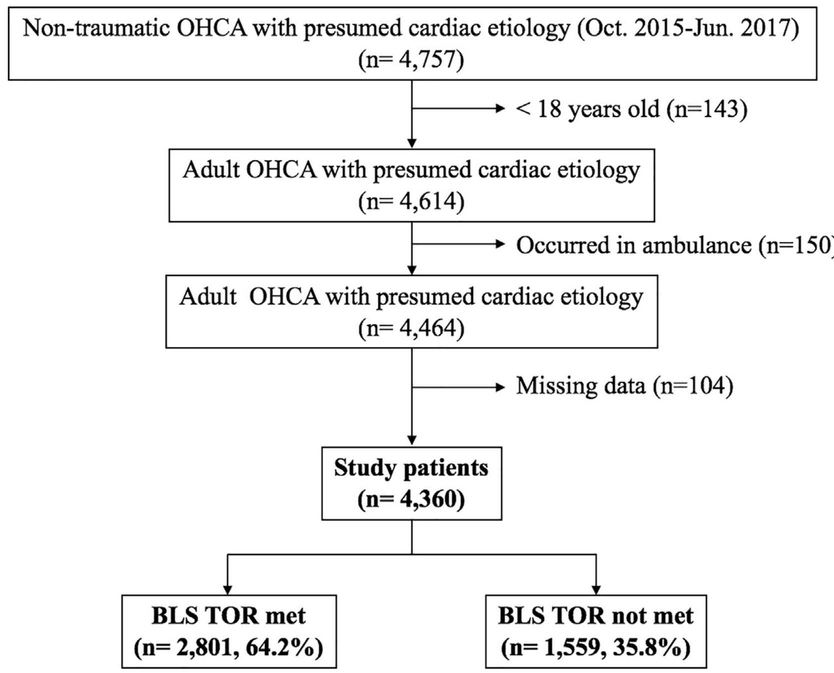
Study population and data collection

EMS-treated, nontraumatic OHCA patients in KoCARC registry from October 2015 to June 2017 were included. We excluded OHCA patient less than 18 years old, OHCAs that occurred in ambulance, and OHCAs with incomplete information. We extracted patient characteristics (age, gender), prehospital characteristics (place of arrest, initial prehospital rhythm, witnessed by bystander or EMS personnel, bystander CPR, automated external defibrillator use and defibrillation, treatments administered by EMS personnel, prehospital *ROSC*, defined as the restoration of a palpable pulse ≥20 minutes), time intervals (*response time* defined as the time from EMS call to scene arrival, *scene time* defined as the time from scene arrival to scene departure, and *transport time* defined as the time from scene departure to hospital arrival), and hospital outcomes from the KoCARC registry. We determined patients who met the TOR rule based on prehospital characteristics. EMS system in Korea was encouraged to provide field resuscitation attempts of at least 5 minutes in compliance with the standard protocols for EMS providers of Korea.[10] The skills allowed for EMS personnel in Korea during CPR to include chest compression, automated external defibrillator use, and intubation. Administration of intravenous epinephrine during CPR is performed by medical instruction. Additionally, EMS personnel could not terminate resuscitation attempts in the field unless the OHCA patients showed obvious signs of death. The *obvious signs of death* are defined as the presence of (1) cut between head and body, (2) corruption, or (3) rigor mortis. So, all EMS-treated OHCA patients should be transported to the ED. The primary end point was a *poor neurological outcome* at hospital discharge defined as a Cerebral Performance Category (CPC) score of 3 (severe disability), 4 (vegetative state), and 5 (death), whereas the secondary outcome was death at hospital discharge.

Statistical analysis

Continuous variables were reported as mean ± SD or median (interquartile rage) depending on result of the normal distribution test. Categorical variables were presented with number and percentages. Continuous variables were compared using Student *t* test or Mann-Whitney test, and categorical variables were compared using χ^2 test between patients with poor neurologic outcome and with good neurologic outcome at the time of hospital discharge in patients who met the TOR rule. And then, we performed binary logistic regression analysis in patients who met all 3 criteria of the TOR rule (n = 2,801) using poor neurologic outcome as dependent variable by including variables showing trend of difference ($P < .20$) in univariate analysis to detect additional independent factors associated with poor neurologic outcome to propose new TOR rules. A receiver operating characteristic curve was used to determine the accuracy of such variables in predicting poor neurologic outcome at discharge. The area under the curve of each variable for poor neurologic outcome at discharge was also calculated. The optimal cutoff value of age was determined using the Youden index, which defines the cutoff in terms of the maximal sum of sensitivity and specificity. However, the cutoff value of scene time interval was determined to achieve 100%

Figure 1



Flowchart of patients.

specificity and PPV for predicting poor neurologic outcome because the BLS TOR rule does not specify a required prehospital resuscitation duration before terminating BLS resuscitative attempts to declare "no ROSC prior to transport." The diagnostic performances of the BLS TOR rule and the new TOR rules were calculated. The new combined TOR rules were made by FPR of the rule (the probability that the rule will suggest termination of resuscitation attempts when the patient survives) and the PPV of the rule (the probability of death when the rule suggests the termination of resuscitation attempts). Current guidelines recommend that when decision to cease life-sustaining care is being considered, tool used to predict poor outcome must be accurate and reliable with an FPR close to 0% with narrow 95% CI (0%-10%).[11,12] Imprecision was graded as serious when the upper limit of the 95% CI of the estimate of FPR was greater than 5% and very serious when this value was more than 10%.[11] *Medical futility* for intervention and drug therapy was defined as imparting a less than 1% chance of survival,[13] namely, PPV should be greater than 99.0%.

Results

Of 4,757 EMS-treated, nontraumatic OHCA patients in KoCARC registry from October 2015 to June 2017, 4,360 OHCA patients were enrolled into the current study. The following cases were excluded: less than 18 years old (n = 143), occurred in ambulance (n = 150), and missing data (n = 104) (Figure 1). Patients were categorized into 2 groups: patients who met all 3 criteria of the BLS TOR rule (n = 2,801, 64.2%) and those who did not (n = 1,559, 35.8%).

Demographic and prehospital characteristics of study patients were presented in Table I. The mean age of study patients was 67.4 years old, and 65.0% were male. OHCA patients who met all 3 criteria of the BLS TOR rule more frequently developed cardiac arrest at home (49.6% vs 72.4%; $P < .001$). Initial shockable arrest rhythm was most frequently seen in OHCA patients who did not met the TOR rule (n = 841, 53.9%), whereas asystole was dominant in OHCA patients who met the TOR rule (n = 2,077, 74.2%). Majority of the OHCA patients were not witnessed by EMS personnel (n = 4,061, 93.1%), did not receive any defibrillation attempt (n = 3,214, 73.7%), and did not achieve ROSC prior to transport (n = 3,773, 86.5%). Of the study patients, 1,131 patients (25.9%) survived to hospital admission, 503 patients (11.5%) survived to hospital discharge, and 399 patients (7.8%) had good neurologic outcome at the time of hospital discharge. Among the patients who met all 3 criteria of the BLS TOR rule, 20 patients (0.7%) showed good neurologic outcome at hospital discharge.

After conducting logistic regression analysis using poor neurologic outcome at the time of hospital discharge as dependent variable in patients who met all 3 criteria of

Table I. Demographic and prehospital characteristics of study population

Variables	Total (N = 4360)	TOR (–) (n = 1559)	TOR (+) (n = 2801)	*P* value
Age, y	67.43 ± 15.80	62.18 ± 15.64	70.21 ± 15.15	<.001
Male, n (%)	2833 (65.0)	1156 (74.2)	1677 (59.9)	<.001
Place of arrest, n (%)				<.001
Home	2800 (64.2)	773 (49.6)	2027 (72.4)	
Public	1560 (35.8)	786 (50.4)	774 (27.6)	
Initial rhythm, n (%)				<.001
VF/pVT	858 (19.7)	841 (53.9)	17 (0.6)	
PEA	828 (19.0)	284 (18.2)	544 (19.4)	
Asystole	2454 (56.3)	377 (24.2)	2077 (74.2)	
Unknown	220 (5.1)	57 (3.7)	163 (5.8)	
Witnessed by EMS, n (%)	299 (6.9)	299 (19.2)	0 (0)	<.001
Witnessed by bystander, n (%)	4008 (91.9)	1246 (79.9)	2762 (98.6)	<.001
Bystander CPR, n (%)	2126 (48.8)	809 (51.9)	1317 (47.0)	.002
Bystander AED use, n (%)	49 (1.1)	33 (2.1)	16 (0.6)	<.001
Bystander defibrillation, n (%)	28 (0.6)	28 (1.8)	0 (0)	<.001
EMS defibrillation, n (%)	1132 (26.0)	1132 (72.6)	0 (0)	<.001
Advanced airway by EMS, n (%)	2340 (53.7)	820 (52.6)	1520 (54.3)	.290
Epinephrine use by EMS, n (%)	656 (15.1)	314 (20.1)	342 (12.2)	<.001
Time interval (min), median (IQR)				
Response time (n = 3799)	7 (5–10)	7 (5–10)	7 (5–10)	.217
Scene time (n = 2863)	12 (8–18)	12 (7–19)	12 (8–17)	.833
Transport time (n = 2860)	10 (7–15)	10 (7–17)	9 (6–14)	<.001
BLS TOR rule, n (%)				
Not witnessed by EMS personnel	4061 (93.1)	1260 (80.8)	2801 (100.0)	<.001
No defibrillation attempt	3214 (73.7)	413 (26.5)	2801 (100.0)	<.001
No ROSC before transport	3773 (86.5)	972 (62.4)	2801 (100.0)	<.001
All met	2801 (64.2)	-	-	-
ECMO use in ED*	33 (0.8)	28 (2.0)	5 (0.2)	<.001
Outcomes				
Hospital admission	1131 (25.9)	708 (45.4)	423 (15.1)	<.001
Survival at hospital discharge	503 (11.3)	406 (26.0)	97 (3.5)	<.001
Good neurologic outcome at hospital discharge	339 (7.8)	319 (20.5)	20 (0.7)	<.001

VF, ventricular fibrillation; *pVT*, pulseless ventricular tachycardia; *PEA*, pulseless ventricular activity; *AED*, automated external defibrillator; *IQR*, interquartile range.
* A total of 450 patients, which consist of 145 in TOR (–) group and 304 in TRO (+) group, were unknown.

Table II. Logistic regression analysis using poor CPC at the time of hospital discharge as dependent variable in the patients who met all criteria of BLS TOR rule (N = 2801)

	Poor CPC at discharge		Univariate analysis		Multivariable analysis	
Variables	Yes (n = 2781)	No (n = 20)	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Age (y), mean ± SD	70.3 ± 15.09	58.4 ± 18.86	1.04 (1.02-1.07)	.001		
Age (>60 y), n (%)	2076 (74.6)	7 (35.0)	5.47 (2.17-13.8)	<.001	5.90 (2.32-14.96)	<.001
Female sex, n (%)	1118 (40.2)	6 (30.0)	1.57 (0.60-4.09)	.358		
Place of arrest, n (%)						
Home	2019 (72.6)	8 (40.0)	1	.003		
Public	762 (27.4)	12 (60.0)	0.25 (0.10-0.62)			
Initial rhythm, n (%)						
VF/pVT	13 (0.5)	4 (20.0)	1			
PEA	534 (19.2)	10 (50.0)	16.97 (4.83-59.62)	.718		
Asystole	2074 (74.6)	3 (15.0)	197.59 (43.29-901.80)	<.001		
Unknown	160 (5.8)	3 (15.0)	15.29 (3.32-70.42)	.972		
Asystole	2074 (74.6)	3 (15.0)	16.62 (4.86-56.89)	<.001	17.50 (5.10-60.08)	<.001
Witnessed by bystander, n (%)	2746 (98.7)	19 (95.0)	3.80 (0.50-29.11)	.199		
Bystander CPR	1310 (47.1)	7 (35.0)	1.65 (0.66-4.16)	.285		
Bystander AED use	16 (0.6)	0 (0)	0.25 (0.01-4.60)	.347		
Response time (n = 2454)	7 (5-10)	8 (6-10)	1.02 (0.94-1.10)	.617		
Scene time (n = 1772)	12 (8-17)	8.5 (6.5-13)	1.11 (0.98-1.25)	.114		

OR, odds ratio.

Table III. New termination of resuscitation rules

TOR rule	Witnessed status	Prehospital shock	Prehospital ROSC	Age (>60 y)	Initial prehospital rhythm
BLS TOR rule	Not witnessed by EMS	No shock delivered	No prehospital ROSC	-	-
KoCARC TOR rule I	Not witnessed by EMS	No shock delivered	No prehospital ROSC	-	Asystole
KoCARC TOR rule II	Not witnessed by EMS	No shock delivered	No prehospital ROSC	Yes	-
KoCARC TOR rule III	Not witnessed by EMS	No shock delivered	No prehospital ROSC	Yes	Asystole

Table IV. Diagnostic performances of TOR rules for predicting poor CPC at the time of hospital discharge

		Poor CPC		Sensitivity	Specificity	FPR	PPV	NPV
TOR rules		Yes	No	(95% CI)	(95% CI)	(95% CI)	(95% CI)	(95% CI)
BLS rule	Met (+)	2781	20	69.2%	94.1%	5.9%	99.3%	20.5%
(n = 4360)	Met (−)	1240	319	(67.7-70.6)	(91.0-96.4)	(3.6-9.0)	(98.9-99.6)	(18.5-22.6)
KoCARC I	Met (+)	2074	3	51.6%	99.1%	0.9%	99.9%	14.7%
(n = 4360)	Met (−)	1947	336	(50.0-53.1)	(97.4-99.8)	(0.2-2.6)	(99.6-100.0)	(14.3-15.1)
KoCARC II	Met (+)	2076	7	51.6%	97.9%	2.1%	99.7%	14.6%
(n = 4360)	Met (−)	1945	332	(50.1-53.2)	(95.8-99.2)	(0.8-4.2)	(99.3-99.8)	(14.1-15.0)
KoCARC III	Met (+)	1536	1	38.2%	99.7%	0.3%	99.9%	12.0%
(n = 4360)	Met (−)	2485	338	(36.7-39.7)	(98.4-100.0)	(0.0-0.6)	(99.6-100.0)	(10.8-13.2)

NPV, negative predictive value.

Table V. Diagnostic performances of TOR rules for predicting death at the time of hospital discharge

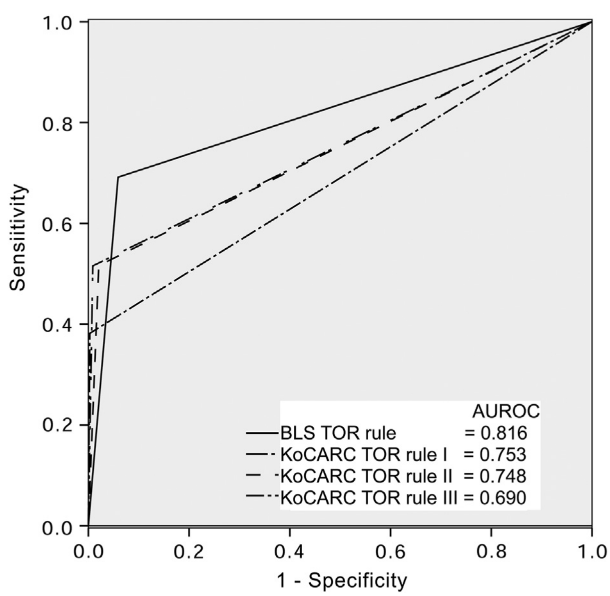
		Death at discharge		Sensitivity	Specificity	FPR	PPV	NPV
TOR rules		Yes	No	(95% CI)	(95% CI)	(95% CI)	(95% CI)	(95% CI)
BLS rule	Met (+)	2704	97	70.1%	80.7%	19.3%	96.5%	26.0%
(n = 4360)	Met (−)	1153	406	(68.6-71.6)	(77.0-84.1)	(15.9-23.0)	(95.8-97.2)	(23.9-28.3)
KoCARC I	Met (+)	2037	40	52.8%	92.1%	7.9%	98.1%	20.3%
(n = 4360)	Met (−)	1820	463	(51.2-54.4)	(89.3-94.3)	(5.7-10.7)	(97.4-98.6)	(19.6-21.0)
KoCARC II	Met (+)	2027	56	52.6%	88.9%	11.1%	97.3%	19.6%
(n = 4360)	Met (−)	1830	447	(51.0-54.1)	(85.8-91.5)	(8.5-14.2)	(96.6-97.9)	(18.9-20.4)
KoCARC III	Met (+)	1512	25	39.2%	95.0%	5.0%	98.4%	16.9%
(n = 4360)	Met (−)	2345	478	(37.7-40.8)	(92.8-96.8)	(3.2-7.2)	(97.6-98.9)	(15.6-18.4)

Met (+) indicates that all criteria are present; and Met (−) does not.

the BLS TOR rule (n = 2,801), we identified age > 60 years old, which was estimated by receiver operating characteristic curves (area under the curve, 0.689) (Supplement Figure 1), and initial asystole in the field as independent factors associated with poor neurologic outcome in patients who met all 3 criteria of the TOR rule (Table II). The new TOR rules (KoCARC TOR rules I, II, III) combining of new variables with the TOR rule were postulated (Table III).

Diagnostic performances of the BLS TOR rule and the new TOR rules for predicting poor neurologic outcome were summarized in Table IV, and those for mortality were in Table V. The receiver operating characteristic curve of the BLS TOR rule and the new TOR rules for poor neurologic outcome is presented in Figure 2. The sensitivity, specificity, FPR, PPV, and NPV of the BLS TOR rule for predicting poor neurologic outcome were 69.2%, 94.1%, 5.9%, 99.3%, and 20.5%, and those for predicting death at hospital discharge were 70.1%, 80.7%, 19.3%, 96.5%, and 26.0% respectively. In terms of criteria of FPR (upper limit of 95% CI < 5%) and PPV (>99%), all new modified TOR rules (KoCARC TOR rules I, II, III) were suitable for predicting poor neurologic outcome in study patients and showed improvement of diagnostic performances compared to those of the BLS TOR rule (Tables IV and V). Overall, KoCARC TOR rule III (BLS TOR rule + initial asystole rhythm + age > 60 years) showed best performances for predicting poor neurologic outcome

Figure 2



Receiver operating characteristic curves of the BLS TOR rule and the new KoCARC TOR rules for predicting poor neurologic outcome at discharge. KoCARC TOR rule I is the combination of 3 previous BLS TOR rule variables with initial asystole; KoCARC TOR rule II is the combination of 3 previous BLS TOR rule variables with age > 60 years; and KoCARC TOR rule III is the combination of 3 previous BLS TOR rule variables with initial asystole and age > 60 yearsAUROC, area under the receiver operating characteristic curve.

and death in study patients. Although the FPRs of KoCARC TOR rules I and III were only 0.9% and 0.3%, respectively, 3 patients from KoCARC TOR rule I and 1 patient from KoCARC TOR rule III had good neurologic outcome at discharge.

Greater than 15 minutes is the cutoff value of scene time interval for achieving 100% specificity and PPV for predicting poor neurologic outcome. Although scene time interval was not an independent variable for poor neurologic outcome, new TOR rules (KoCARC TOR rules 4, 5, 6) including the application time (scene time interval ≥ 15 minutes) were suitable for poor neurologic outcome and death (Supplement Table I, II, and III).

Discussion

This validation of BLS TOR rule using 4,360 OHCA patients from a prospective nationwide registry indicates a relatively high FPR (5.9%) for poor neurologic outcome. We identified the associated factors (initial asystole and age > 60 years) with poor neurologic outcome and found that the new KoCARC TOR rules, combining these factors with previous TOR rule, have the lowest FPR and highest PPV value for predicting poor neurologic outcome.

Previous validations of TOR rule reported survival rates of less than 1% among TOR rule–positive patients in North America; however, high FPR of survival have been reported in Asian countries (28.7% [95% CI 8.9%-25.3%] in Singapore,[2] 25.9% [95% CI 20.0%-32.7%] in Taiwan,[4] 30.4% [95% CI 26.2%-34.9%] in Korea[5]). This discrepancy is possibly by different prehospital practice and relatively high prevalence of nonshockable rhythm in Asian countries.[4,5] However, high FPRs of survival from these Asian countries where the withdrawal of life-sustaining treatment is not commonly applied are likely to be biased. Kajino et al validated TOR rules for predicting poor neurologic outcome in Japanese population, and they concluded that more specific TOR rules for each region would be developed despite good performance of TOR rules.[3] In our study with the most recent cohort validation of TOR rule for poor neurological status, as a primary outcome, we found 5.9% FPR and 99.3% PPV of TOR rule for predicting poor neurologic outcome. These results implied that extrapolation to and implementation in regions with different organization of EMS, treatment protocols, legislation, and socioeconomic characteristics may be problematic so that the original North American TOR rules needed to be adjusted to meet the regional situation.

We identified independent variables (initial asystole and age > 60 years) associated with poor neurologic outcome in patients met all 3 criteria of the BLS TOR rule. The Survey of Survivors after Cardiac Arrest–KANTO study group also selected asystole in the field and at ED arrival as new variable for new TOR rule for emergency physician to detect futile resuscitation in the ED, replacing the criterion of BLS TOR rule "no shock delivered."[14] A recent TOR validation report found that 7.3% (47/644) of patients with initial shockable rhythms were not given shock subsequently for unknown reasons.[15] This suggests that accurate interpretation of arrest rhythm and application of appropriate field resuscitation might be difficult and impossible even in well-established EMS system. Also, our data showed that 2.0% of patients with initial shockable rhythm were classified into TOR-met group. The KoCARC TOR rule I used asystole as a component of rule in addition to no shock delivered. It showed better FPR than that of the BLS TOR rule (0.9% vs 5.9%).

Increasing patient age has been associated with less favorable neurological outcomes[15-18]; however, older age alone does not seem to be a good criterion for denying patients CPR, and a specific cutoff value of age is still being debated. In our study, we found age > 60 years was associated with less favorable neurologic outcome from multivariable analysis. However, our cutoff value of age > 60 years was determined according to receiver operating characteristic curves (area under the curve, 0.689), which showed moderate performance for predicting poor neurologic outcome. Although modifying the TOR rule to account for patient's characteristics such as age seems reasonable, it is often difficult to determine the age of OHCA patients in prehospital setting. According to our results, the KoCARC TOR rule III (combining 3 previous BLS TOR rule variables with initial asystole and age > 60 years) has the best performance for poor neurologic outcome (0.3% FPR and 99.9% PPV); however, KoCARC TOR rule I (without age variable) is more useful in this situation.

Applying time for declaration of no achievement of prehospital ROSC could alter the accuracy of the BLS TOR rule.[1,19-21] In a recent study showed that application of the BLS TOR rule at 6 minutes of resuscitation reported 2.1% of patients who met all criteria of the BLS TOR rule survived finally. But they found that delayed application of the BLS TOR rule improved PPV and FPR of the rule.[22] Moreover, the 2000 National Association of EMS Physicians position statement on TOR recommended that prehospital termination of resuscitation could be considered after full resuscitative efforts which included provision of 20–30 minutes of treatment.[23] In our study, scene time interval was not associated with neurologic outcomes, but scene time interval ≥ 15 minutes is the cutoff value for achieving 100% specificity and PPV for predicting poor neurologic outcome. KoCARC TOR rules with scene time interval ≥ 15 minutes (IV, V, VI) showed 0% FPR and 100% PPV for predicting poor neurologic outcome (Supplement Table II). However, KoCARC TOR rules IV, V, and VI make the number of TOR-met patients decrease from 1537-2083 (35.3%-47.8%) to 323-443 (11.3%-15.5%). The missing value of scene time interval data should be interpreted with caution in light of its limitations and might be insufficient to draw reference to.

There are several strengths and limitations. We validated TOR rule with prospective, nationwide cohort OHCA from 2015 to 2017, with the recent population reflecting current CPR circumstances such as ECMO and duration of CPR. Moreover, poor neurologic outcome as a primary outcome is more suitable than survival discharge. However, data integrity, validity, and ascertainment bias are potential limitation as with all observational studies. Data collection was achieved by coordinator of each hospital using Utstein template to minimize these problems. Also, although our registry enrolled the OHCA patients presenting to 62 EDs, majority of high-level EDs throughout Korea, OHCAs that occurred in rural region were less likely enrolled in our registry. Because missing data especially regarding scene time interval (36.7%) were a significant limitation of our study, we have suggested the scene time interval as supplementary criterion rather than our main findings. Those missing data may confound the results and should be interpreted with caution. Additionally, assessment of age is challenging in prehospital setting, and physiological age reflects the patient state better than chronological age. However, our study aimed to minimize the possibility of missed potential survivors unless it is obviously medically futile. Finally, all physicians treated the OHCA patients according to the current guidelines, but applying in-hospital interventions such as ECMO, TTM, or coronary reperfusion therapy, which could affect the outcome, was not standardized between the participating hospitals.

In conclusion, the current BLS TOR rule showed high FPR (5.9%) for predicting poor neurologic outcome in Korean population. We anticipate that our new KoCARC TOR rules, application of 2 new factors (initial asystole and age > 60 years), could modify TOR rule for reducing the possibility of missed potential survivors with good neurologic outcome, especially in Korea.

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Disclosures

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