

IMPACT OF A TARGETED TEMPERATURE MANAGEMENT QUALITY IMPROVEMENT PROJECT ON SURVIVAL AND NEUROLOGIC OUTCOMES IN CARDIAC ARREST PATIENTS

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INTRODUCTION

Targeted temperature management (TTM) has been recommended for post-resuscitation care of patients with sudden cardiac arrest (SCA) and the implementation of TTM remains challenging. This study aimed to evaluate the newly designed Quality Improvement Project (QIP) to improve the quality of TTM and outcomes of patients with SCA.

METHOD

Patients experiencing out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrest (IHCA) with return of spontaneous circulation (ROSC) and who were treated in our hospital between January 2017 and December 2019 were enrolled retrospectively. QIP was initiated as follows:

- 1) creating protocols and standard operating procedures for TTM;
- 2) documenting shared decision making;
- 3) creating job training instruction;
- 4) starting lean medical management.

Table 1 - Baseline characteristics for cardiac arrest patients between preintervention and postintervention groups

Variables	Preintervention (N = 144)	Postintervention (N = 104)	P
Male sex no./total no. (%)	86/144 (45.8%)	54/104 (51.9%)	0.344
Mean age, y (± SD)	67.1 ± 15.1	64.5 ± 16.1	0.205
Comorbidities no./total no. (%)			
Diabetes mellitus	79/144 (54.9%)	49/104 (47.1%)	0.554
Hypertension	79/144 (54.9%)	58/104 (55.8%)	0.897
Coronary artery disease	26/144 (18.1%)	19/104 (18.3%)	0.996
Dyslipidemia	17/144 (11.8%)	12/104 (11.5%)	0.949
Heart failure	14/144 (9.7%)	11/104 (10.6%)	0.855
Arrhythmia	8/144 (5.6%)	6/104 (5.8%)	0.963
Chronic kidney disease	17/144 (11.8%)	19/104 (18.3%)	0.154
End-stage renal disease	17/144 (11.8%)	18/104 (17.3%)	0.219
under dialysis	14/144 (9.7%)	7/104 (6.7%)	0.404
Cerebral vascular disease	17/144 (11.8%)	16/104 (15.4%)	0.413
Malignancy	5/144 (3.5%)	3/104 (2.8%)	0.598
Chronic obstructive pulmonary disease or asthma	3/144 (2.1%)	2/104 (1.9%)	0.929
Witnessed collapse	78/144 (54.2%)	50/104 (48.1%)	0.344
Out-of-hospital cardiac arrest	123/144 (85.4%)	90/104 (86.6%)	0.802
Bystander cardiopulmonary resuscitation	93/144 (64.6%)	79/104 (76.0%)	0.055
Defibrillation by AED	14/144 (9.7%)	8/104 (7.7%)	0.823
Initial rhythm no./total no. (%)			0.467
Ventricular tachycardia/ Ventricular fibrillation	16/144 (11.1%)	9/104 (8.7%)	
Asystole	102/144 (70.8%)	70/104 (67.3%)	
Pulseless electrical activity	26/144 (18.1%)	25/104 (24.0%)	
Electrical shock no./total no. (%)	33/144 (22.9%)	24/104 (23.1%)	0.874
Sustained return of spontaneous circulation (>20 min)	141/144 (97.9%)	103/104 (99.0%)	0.489
Glasgow Coma Scale at ROSC (μ ± SD)	3.58 ± 1.5	3.29 ± 1.2	0.095
Heart rate at ROSC (μ ± SD)	105.2 ± 29.1	102.2 ± 26.9	0.337
Systolic blood pressure at ROSC (μ ± SD)	125.5 ± 45.4	125.2 ± 45.9	0.919
Diastolic blood pressure at ROSC (μ ± SD)	73.5 ± 29.1	68.9 ± 29.0	0.391
Body temperature at ROSC (μ ± SD)	35.5 ± 1.2	35.7 ± 1.3	0.409
Treatments no./total no. (%)			
Extracorporeal membrane oxygenation	5/144 (3.5%)	10/104 (9.6%)	0.016
Coronary angiography	12/144 (8.3%)	13/104 (12.5%)	0.160
Percutaneous coronary intervention	11/144 (7.6%)	12/104 (11.5%)	0.574

Table 2 - Baseline characteristics for cardiac arrest patients between survivors vs nonsurvivors

Variables	Survivors (N = 80)	Nonsurvivors (N = 168)	P
Male sex no./total no. (%)	45/80 (56.3%)	91/168 (54.2%)	0.543
Mean age, y (± SD)	63.9 ± 15.8	67.3 ± 15.1	0.321
Comorbidities no./total no. (%)			
Diabetes mellitus	41/80 (51.3%)	89/168 (52.9%)	0.613
Hypertension	46/80 (57.5%)	91/168 (54.2%)	0.873
Coronary artery disease	19/80 (23.8%)	26/168 (15.5%)	0.091
Dyslipidemia	9/80 (11.3%)	20/168 (11.9%)	0.983
Heart failure	7/80 (8.8%)	22/168 (13.1%)	0.882
Arrhythmia	5/80 (6.3%)	7/168 (4.2%)	0.917
Chronic kidney disease	11/80 (13.8%)	25/168 (14.9%)	0.257
End-stage renal disease	9/80 (11.3%)	26/168 (15.5%)	0.163
Cerebral vascular disease	9/80 (11.3%)	12/168 (7.1%)	0.431
Malignancy	10/80 (12.5%)	23/168 (13.7%)	0.459
Chronic obstructive pulmonary disease or asthma	3/80 (3.8%)	7/168 (4.2%)	0.589
Witnessed collapse	2/80 (2.5%)	3/168 (1.8%)	0.826
Out-of-hospital cardiac arrest	47/80 (58.8%)	81/168 (48.2%)	0.242
Witnessed collapse	73/80 (91.3%)	92/168 (54.8%)	0.001
Bystander cardiopulmonary resuscitation	71/80 (88.8%)	92/168 (54.8%)	0.001
Defibrillation by AED	8/80 (10.0%)	14/168 (8.3%)	0.518
Initial rhythm no./total no. (%)			
Ventricular tachycardia/ Ventricular fibrillation	10/80 (12.5%)	15/168 (8.9%)	
Asystole	61/80 (76.3%)	113/168 (67.3%)	
Pulseless electrical activity	16/80 (20.0%)	35/168 (20.8%)	
Electrical shock no./total no. (%)	19/80 (23.8%)	37/168 (22.0%)	0.897
Sustained return of spontaneous circulation (>20 min)	79/80 (98.8%)	165/168 (98.2%)	0.589
Glasgow Coma Scale at ROSC (μ ± SD)	2.73 ± 1.7	2.4 ± 1.1	0.063
Heart rate at ROSC (μ ± SD)	100.4 ± 25.5	101.9 ± 27.3	0.234
Systolic blood pressure at ROSC (μ ± SD)	125.6 ± 51.4	107.2 ± 43.1	0.506
Diastolic blood pressure at ROSC (μ ± SD)	76.4 ± 28.4	61.9 ± 24.3	0.409
Body temperature at ROSC (μ ± SD)	35.0 ± 1.2	35.7 ± 1.3	0.409
Treatments no./total no. (%)			
Extracorporeal membrane oxygenation	5/80 (6.3%)	10/168 (6.0%)	0.616
Coronary angiography	12/80 (15.0%)	13/168 (7.8%)	0.160
Percutaneous coronary intervention	11/80 (13.8%)	12/168 (7.1%)	0.574

Table 3 - Baseline characteristics for cardiac arrest patients between better neurological vs worse neurological outcome

Variables	Better neurological outcome (N = 17)	Worse neurological outcome (N = 63)	P
Male sex no./total no. (%)	8/17 (47.1%)	31/63 (49.2%)	0.834
Mean age, y (± SD)	64.7 ± 15.9	67.5 ± 16.1	0.310
Comorbidities no./total no. (%)			
Diabetes mellitus	9/17 (52.9%)	32/63 (50.8%)	0.354
Hypertension	10/17 (58.8%)	26/63 (41.3%)	0.007
Coronary artery disease	3/17 (17.6%)	16/63 (25.4%)	0.789
Dyslipidemia	2/17 (11.8%)	7/63 (11.1%)	0.932
Heart failure	2/17 (11.8%)	5/63 (7.9%)	0.857
Arrhythmia	1/17 (5.9%)	4/63 (6.3%)	0.872
Chronic kidney disease	3/17 (17.6%)	8/63 (12.7%)	0.216
End-stage renal disease under dialysis	2/17 (11.8%)	7/63 (11.1%)	0.825
Cerebral vascular disease	2/17 (11.8%)	7/63 (11.1%)	0.825
Malignancy	1/17 (5.9%)	2/63 (3.2%)	0.449
Chronic obstructive pulmonary disease or asthma	1/17 (5.9%)	1/63 (1.6%)	0.521
Out-of-hospital cardiac arrest	9/17 (52.9%)	38/63 (60.3%)	0.446
Witnessed collapse	15/17 (88.2%)	58/63 (92.1%)	0.802
Bystander cardiopulmonary resuscitation	17/17 (100%)	55/63 (87.3%)	0.048
Defibrillation by AED	2/17 (11.8%)	6/63 (9.5%)	0.823
Initial rhythm no./total no. (%)			0.567
Ventricular tachycardia/ Ventricular fibrillation	2/17 (11.8%)	8/63 (12.7%)	
Asystole	12/17 (70.6%)	49/63 (77.8%)	
Pulseless electrical activity	3/17 (17.6%)	12/63 (19.0%)	
Electrical shock no./total no. (%)	4/17 (23.5%)	13/63 (20.6%)	0.754
Sustained return of spontaneous circulation (>20 min)	17/17 (100%)	61/63 (96.8%)	0.438
Glasgow Coma Scale at ROSC (μ ± SD)	3.49 ± 1.4	2.58 ± 1.3	0.005
Heart rate at ROSC (μ ± SD)	104.3 ± 22.1	102.2 ± 24.1	0.337
Systolic blood pressure at ROSC (μ ± SD)	127.5 ± 34.7	125.5 ± 42.6	0.879
Diastolic blood pressure at ROSC (μ ± SD)	78.1 ± 23.5	69.2 ± 26.8	0.370
Body temperature at ROSC (μ ± SD)	35.7 ± 1.2	35.0 ± 1.1	0.396
Treatments no./total no. (%)			
Extracorporeal membrane oxygenation	6/17 (35.3%)	9/63 (14.3%)	0.137
Coronary angiography	5/17 (29.4%)	20/63 (31.7%)	0.668
Percutaneous coronary intervention	5/17 (29.4%)	18/63 (28.6%)	0.774

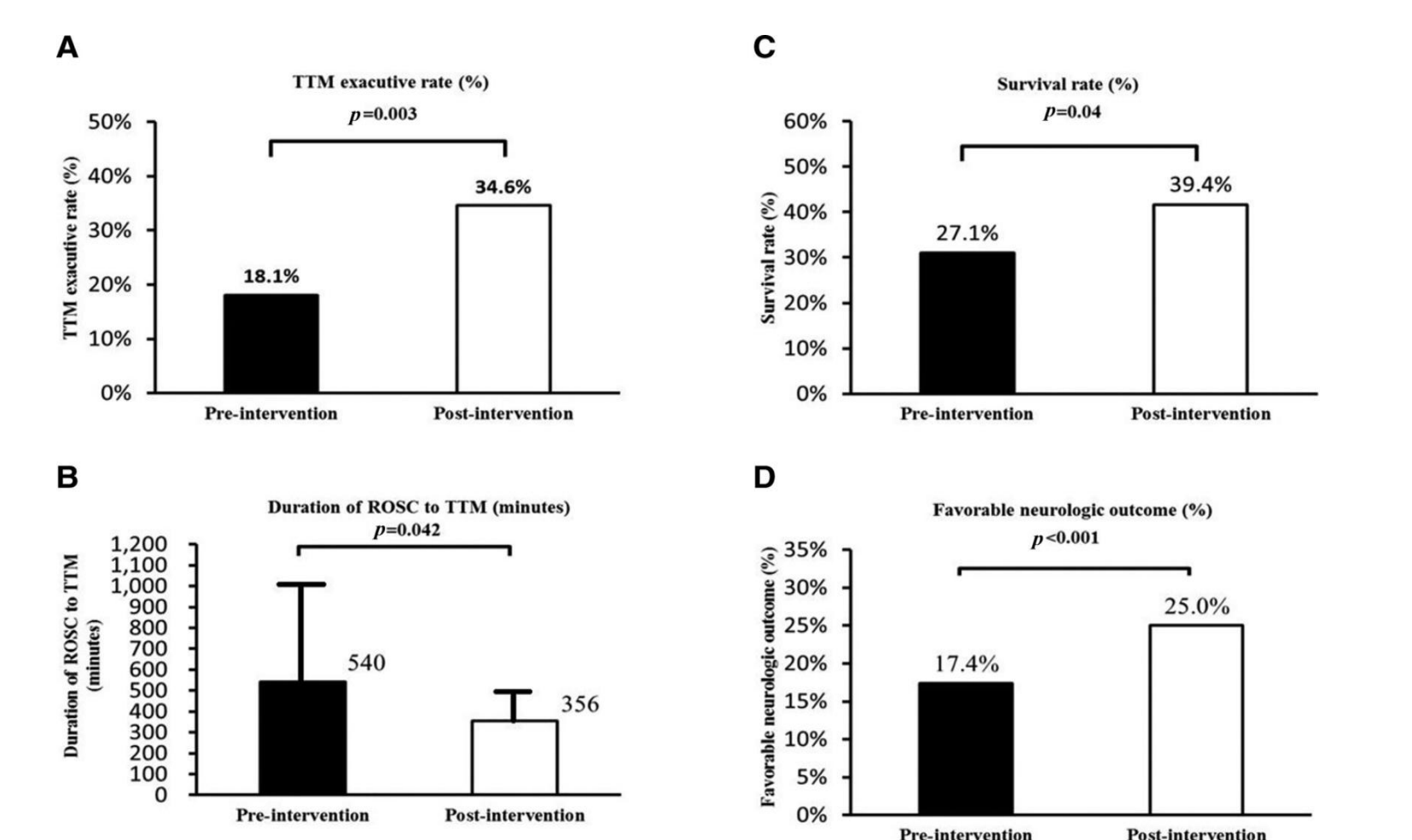


Fig. 6 Outcomes of cardiac arrest patients between preintervention (n = 144) and postintervention (n = 104) groups. A, Postintervention group had higher TTM execution rate than the preintervention group (execution rate of preintervention: 18.1%; postintervention: 34.6%, $p = 0.003$). B, Longer duration of ROSC to TTM was observed in the preintervention group (duration of preintervention: 540 ± 438 minutes; postintervention: 356 ± 155 minutes, $p = 0.042$). C, Higher survival rate to discharge was observed in the postintervention group (survival rate of preintervention: 27.1%; postintervention: 39.4%, $p = 0.04$). D, In the preintervention group, low favorable neurologic outcomes were reported (preintervention: 17.4%; postintervention: 25.0%, $p < 0.001$). ROSC = return of spontaneous circulation; SD = standard deviation; TTM = targeted temperature management.

Table 4 - Baseline characteristics for cardiac arrest patients between the TTM and non-TTM groups after propensity score matching

Variables	Non-TTM (N = 48)	TTM (N = 48)	P
Male sex no./total no. (%)	30/48 (62.5%)	29/48 (60.4%)	0.834
Mean age, y (± SD)	62.5 ± 15.0	61.1 ± 12.0	0.611
Comorbidities no./total no. (%)			
Diabetes mellitus	25/48 (52.1%)	23/48 (47.9%)	0.683
Hypertension	30/48 (62.5%)	30/48 (62.5%)	1.0
Coronary artery disease	7/48 (14.6%)	10/48 (20.8%)	0.423
Dyslipidemia	7/48 (14.6%)	9/48 (18.8%)	0.584
Heart failure	5/48 (10.4%)	7/48 (14.6%)	0.537
Arrhythmia	3/48 (6.3%)	2/48 (4.2%)	0.646
Chronic kidney disease	5/48 (10.4%)	7/48 (14.6%)	0.537
End-stage renal disease under dialysis	5/48 (10.4%)	3/48 (6.3%)	0.460
Cerebral vascular disease	4/48 (8.3%)	5/48 (10.4%)	0.726
Malignancy	2/48 (4.2%)	1/48 (2.1%)	0.557
Chronic obstructive pulmonary disease or asthma	1/48 (2.1%)	1/48 (2.1%)	1.0
Out-of-hospital cardiac arrest	41/48 (85.4%)	36/48 (75.0%)	0.200
Witnessed collapse	36/48 (75.0%)	41/48 (85.4%)	0.200
Bystander cardiopulmonary resuscitation	37/48 (77.1%)	37/48 (77.1%)	<0.001
Defibrillation by AED	10/48 (20.8%)	12/48 (25.0%)	0.197
Initial rhythm			0.248
Ventricular tachycardia/ventricular fibrillation	9/48 (18.8%)	14/48 (29.2%)	
Asystole	33/48 (68.8%)	25/48 (52.1%)	
Pulseless electrical activity	6/48 (12.5%)	9/48 (18.8%)	
Electrical shock	13/48 (27.1%)	17/48 (35.4%)	0.378
Sustained return of spontaneous circulation (>20 min)	46/48 (95.8%)	48/48 (100%)	0.153
Glasgow Coma Scale at ROSC (μ ± SD)	3.29 ± 2.3	2.35 ± 1.1	0.019
Heart rate at ROSC (μ ± SD)	107.6 ± 30.1	100.0 ± 26.3	0.392
Systolic blood pressure at ROSC (μ ± SD)	118.9 ± 46.2	123.5 ± 46.6	0.613
Diastolic blood pressure at ROSC (μ ± SD)	70.0 ± 29.9	72.0 ± 30.4	0.748
Body temperature at ROSC (μ ± SD)	35.3 ± 1.4	36.1 ± 1.3	0.499
Treatments			
Extracorporeal membrane oxygenation	0/48 (0%)	4/48 (8.3%)	<0.001
Coronary angiography	0/48 (0%)	12/48 (25.0%)	<0.001
Percutaneous coronary intervention	0/48 (0%)	11/48 (22.9%)	<0.001

Values are expressed as mean (μ) ± standard deviation for continuous variables and numbers (N) for categorical variables. AED = automated external defibrillator; ROSC = return of spontaneous circulation; SD = standard deviation; TTM = targeted temperature management.

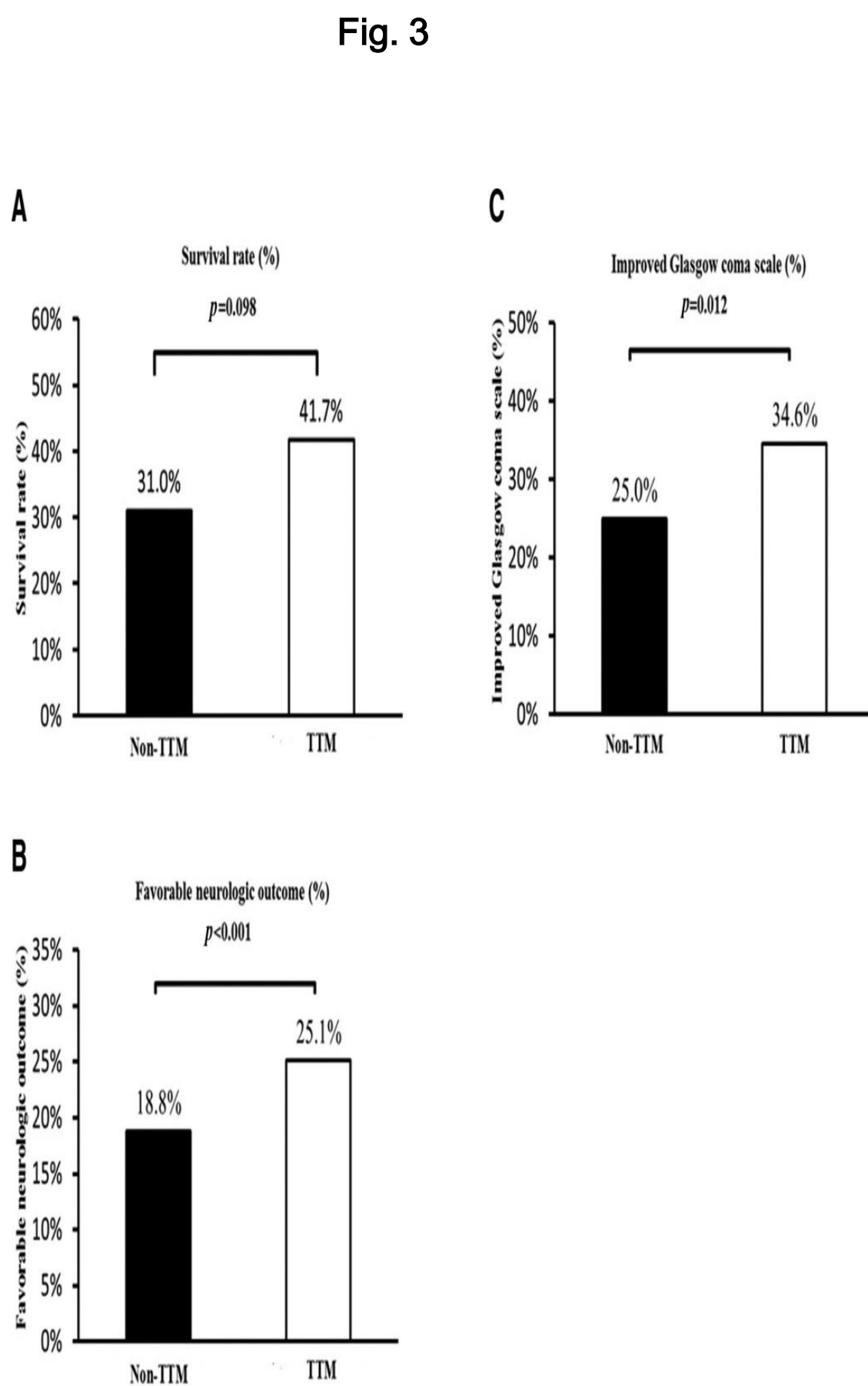


Fig. 8 Outcomes of cardiac arrest patients between the targeted temperature management (TTM) and non-TTM groups after propensity score matching. A, TTM group (n = 48) had higher favorable neurologic outcomes (non-TTM: 18.8%; TTM: 25.0%, $p < 0.001$). B, Non-TTM group (n = 200) had poor survival rate to discharge, but without statistical significance (survival rate of non-TTM: 31.3%; TTM: 41.7%, $p = 0.098$). C, TTM group had a higher rate of improved Glasgow coma scale scores (non-TTM: 25%; TTM: 34.6%, $p = 0.012$). TTM = targeted temperature management.

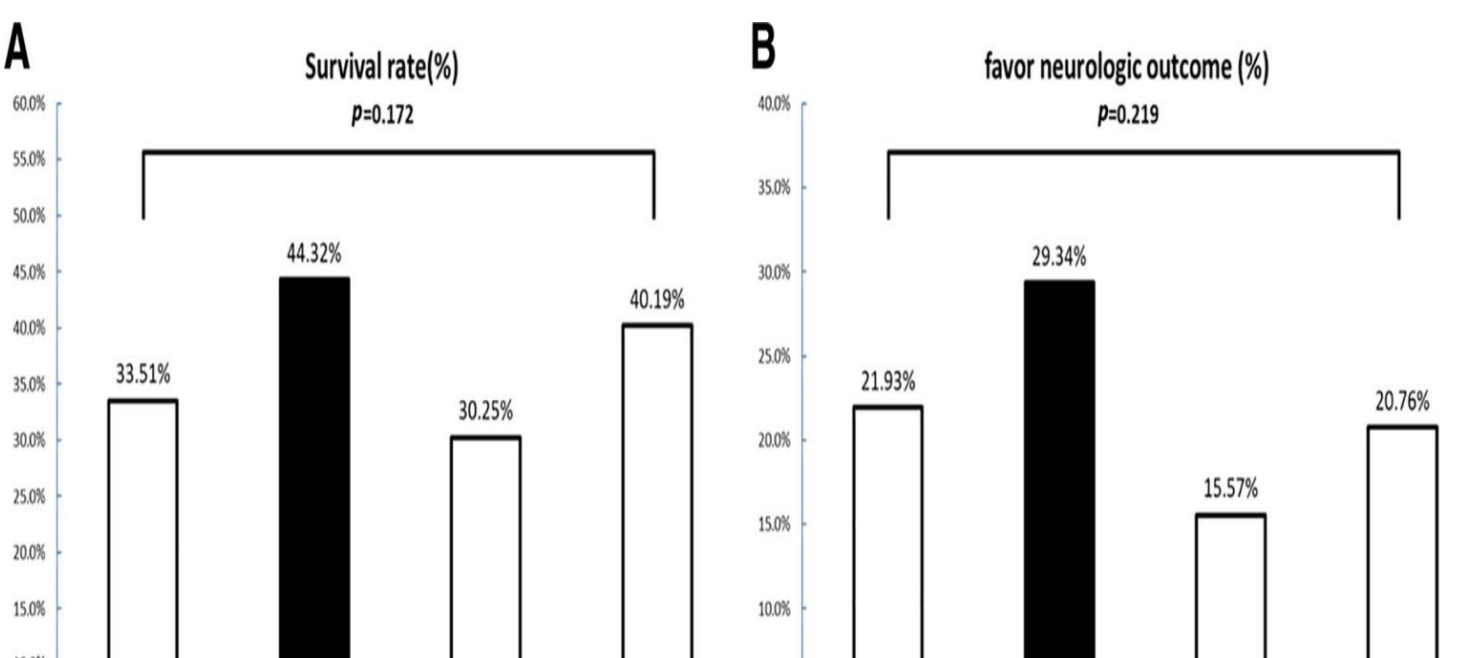


Fig. 9 Survival rate of cardiac arrest patients between QIP+TTM-, QIP+TTM+, QIP-TTM-, and QIP-TTM+ groups. QIP+TTM+ group had higher survival rate than other groups but without statistical significance. (QIP+TTM-: 33.5%, QIP+TTM+: 44.3%, QIP-TTM-: 30.2% and QIP-TTM+: 40.1%, $p = 0.172$). Receiving QIP without TTM- was 33.5%, receiving QIP with TTM was 44.3% and not receiving QIP nor TTM was 30.2%, and not receiving QIP but receiving TTM was 40.1%. QIP = Quality Improvement Project; TTM = targeted temperature management.

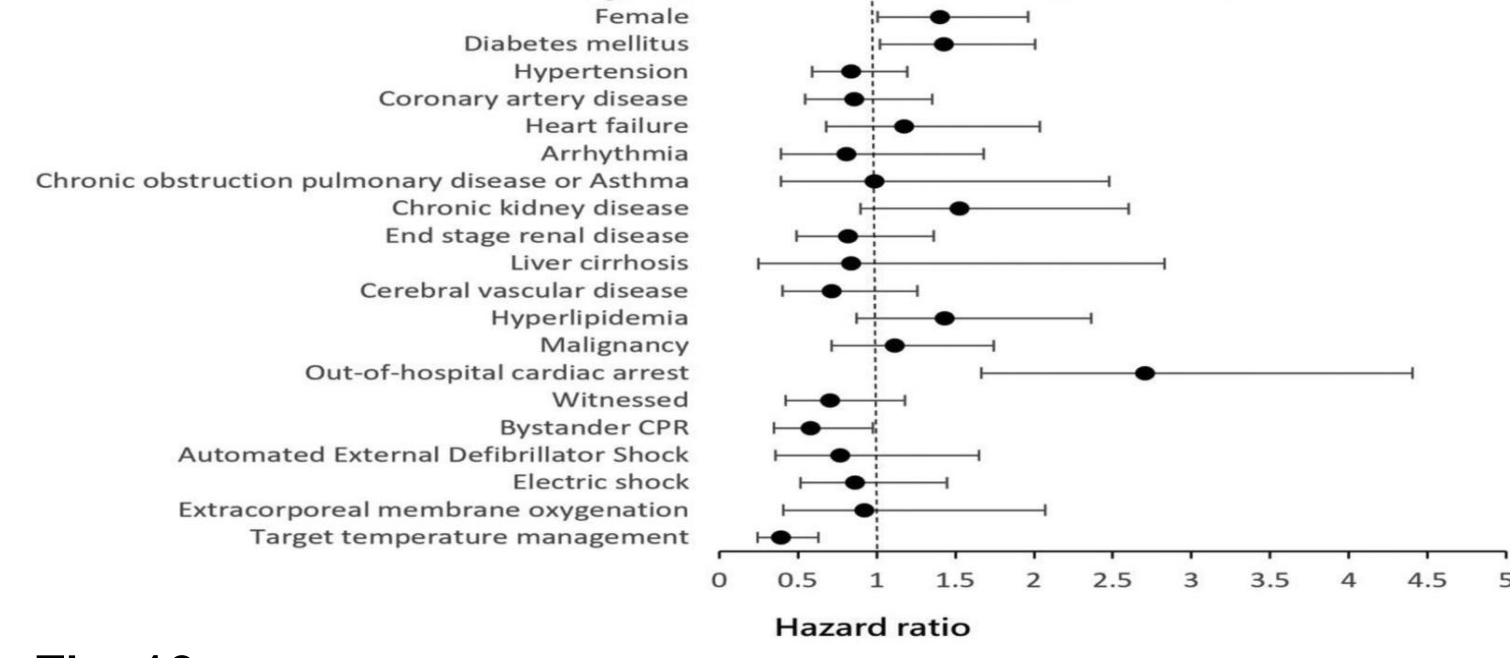


Fig. 10 Cox regression analysis of survival outcomes in cardiac arrest patients. Total number was 248 patients and those with survival to discharge was 80. Forest plot of cardiac arrest patients. Out-of-hospital cardiac arrest (OR = 2.705, 95% CI: 1.657-4.416) and age >60 (OR = 2.154, 95% CI: 1.428-3.244) and female (OR = 1.404, 95% CI: 1.005-1.962) and diabetes mellitus (OR = 1.429, 95% CI: 1.019-2.005) were negative predictors of mortality, while target temperature management (OR = 0.431, 95% CI: 0.266-0.699) and bystander CPR (OR = 0.589, 95% CI: 0.350-0.990) were positive predictors for overall outcomes. AED = automated external defibrillator; CA = cardiac arrest; CPR = cardiopulmonary resuscitation; ECMO = extracorporeal membrane oxygenation; OHCA = out-of-hospital cardiac arrest; OR = odds ratio.

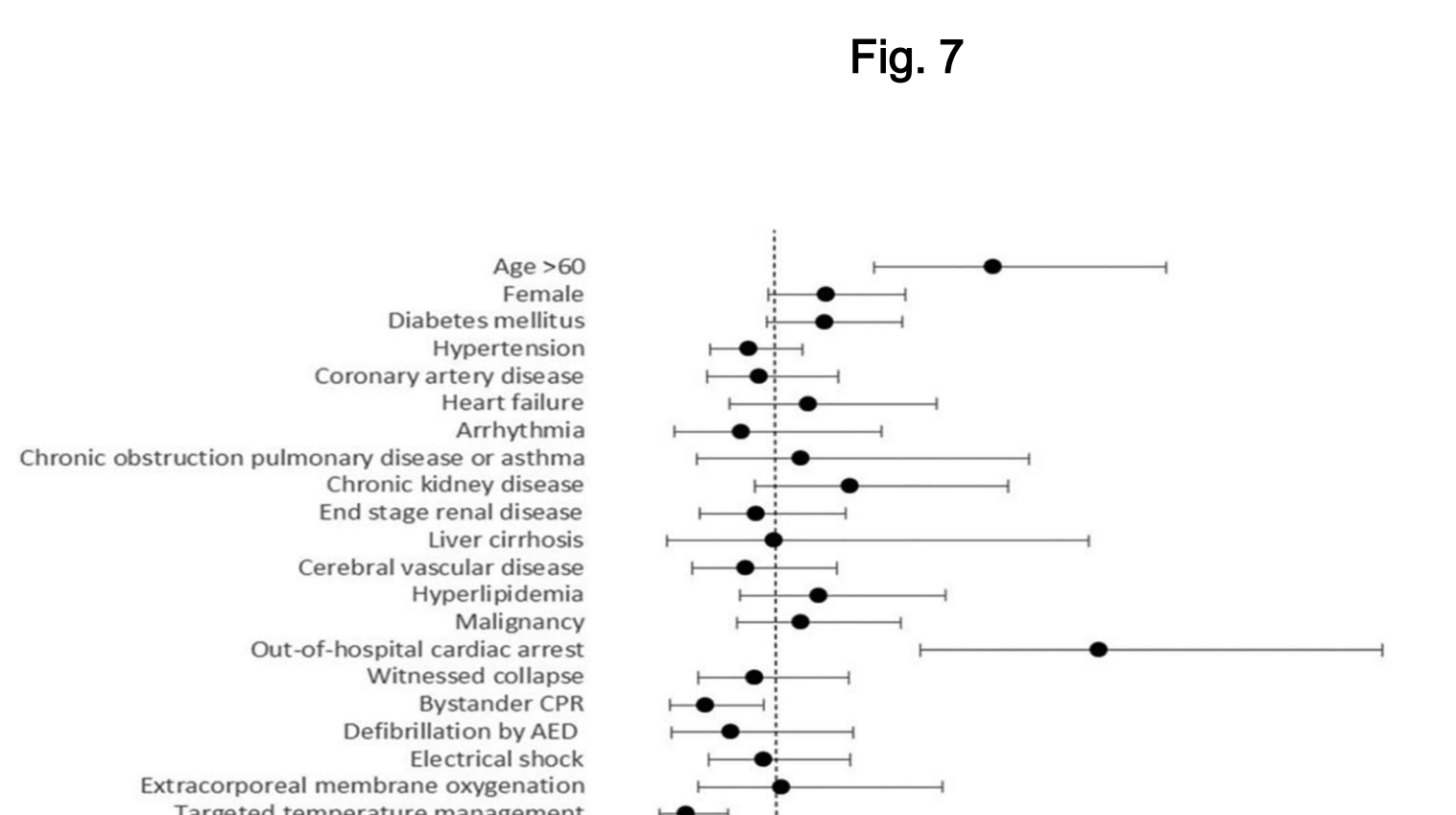


Fig. 11 Cox regression analysis of favorable neurologic outcomes in cardiac arrest patients. Age >60 (OR = 2.292, 95% CI: 1.580-3.323) and out-of-hospital cardiac arrest (OR = 2.928, 95% CI: 1.858-4.616) were negative predictors, while bystander CPR (OR = 0.572, 95% CI: 0.355-0.922) and TTM (OR = 0.457, 95% CI: 0.296-0.705) were positive predictors for favorable neurologic outcomes. AED = automated external defibrillator; CA = cardiac arrest; CI = confidence interval; CPR = cardiopulmonary resuscitation; ECMO = extracorporeal membrane oxygenation; OHCA = out-of-hospital cardiac arrest; OR = odds ratio; TTM = targeted temperature measurement.

CONCLUSIONS

A new QIP with defined protocols, documented shared decision making and medical management guidelines improves the execution rate of TTM, duration from ROSC to TTM, survival, and neurologic outcomes of cardiac arrest patients.