The Postcardiac Arrest Consult Team: Impact on Hospital Care Processes for Out-of-Hospital Cardiac Arrest Patients

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Objective: To evaluate whether a Post-Arrest Consult Team improved care and outcomes for patients with out-of-hospital cardiac arrest.

Design: Prospective cohort study of Post-Arrest Consult Team implementation at two hospitals, with concurrent controls from 27 others.

Setting: Twenty-nine hospitals within the Strategies for Post-Arrest Care Network of Southern Ontario, Canada.

Patients: We included comatose adult nontraumatic out-of-hospital cardiac arrest patients surviving more than or equal to 6 hours after emergency department arrival who had no contraindications to targeted temperature management.

Intervention: The Post-Arrest Consult Team was an advisory consult service to improve 1) targeted temperature management, 2) assessment for percutaneous coronary intervention, 3) electrophysiology assessment, and 4) appropriately delayed neuroprognostication.

Measurements and Main Results: We used generalized linear mixed models to explore the association between Post-Arrest Consult Team implementation and performance of targeted processes. We included 1,006 patients. The Post-Arrest Consult Team was

associated with a significant reduction over time in rates of withdrawal of life-sustaining therapy within 72 hours of emergency department arrival on the basis of predictions of poor neurologic prognosis (ratio of odds ratios, 0.13; 95% CI, 0.02–0.98). Post-Arrest Consult Team was not associated with improved successful targeted temperature management (ratio of odds ratios, 0.91; 95% CI, 0.31–2.65), undergoing angiography (ratio of odds ratios, 1.91; 95% CI, 0.17–21.04), receiving electrophysiology consultation (ratio of odds ratios, 0.93; 95% CI, 0.11–8.16), or functional survival (ratio of odds ratios, 0.75; 95% CI, 0.19–2.94).

Conclusions: Implementation of a Post-Arrest Consult Team reduced premature withdrawal of life-sustaining therapy but did not improve rates of successful targeted temperature management, coronary angiography, formal electrophysiology assessments, or functional survival for comatose patients after out-of-hospital cardiac arrest. (*Crit Care Med* 2016; XX:00–00)

Key Words: death, sudden; health services; heart arrest; hypothermia, induced; patient care team

Out-of-hospital cardiac arrest (OHCA) is a significant public health problem. There are approximately 464,000 OHCA patients assessed by emergency medical services (EMS) every year in the United States and Canada. Approximately one quarter of these patients are initially resuscitated and survive to hospital admission (1, 2), and only 37% of these admitted patients survive to hospital discharge.

Targeted temperature management (TTM), assessment for acute coronary syndrome, the avoidance of premature neuroprognostication, and electrophysiology assessment are important components of optimal postcardiac arrest care (3–5); however, these practices are followed inconsistently (6–9). Current guidelines suggest that optimized postcardiac arrest care should be facilitated by a collaborative and multidisciplinary team of care providers (5).

Specialized interdisciplinary teams have been effective in improving care in other types of emergencies such as trauma and ST-elevation myocardial infarction (STEMI) (10–15); however, data on specialized teams for postcardiac arrest patients are limited.

We implemented a Post-Arrest Consult Team (PACT) at two urban academic centers in Canada to directly address barriers to optimal care delivery for postcardiac arrest patients. Our objective was to measure changes in care processes and clinical outcomes associated with implementation of the PACT.

METHODS

Design

This was a prospective observational study with concurrent controls.

Setting

The Strategies for Post-Arrest Care (SPARC) Network is a collaborative network of hospitals within Southern Ontario formed with the goal of improving care processes and outcomes for patients after OHCA (16, 17). The network catchment area includes the City of Toronto and several adjacent regions including a population of 6.6 million. PACT teams were implemented in two academic health sciences centers within the SPARC Network. PACT hospital A is a regional trauma center with over 500 acute care beds and 57,000 emergency department (ED) visits per year. PACT hospital B is also a regional trauma center with close to 500 acute care beds and 71,000 annual ED visits. Hospitals were selected for PACT implementation on the basis of preexisting working relationships between the investigator team and the hospitals. All 27 remaining hospitals actively participating in the SPARC Network formed the control group.

Patient Selection

Patients were included if they were 18 years or older, suffered a nontraumatic OHCA, were treated by EMS personnel, arrived at a SPARC hospital, were comatose on arrival to the hospital (documented Glasgow Coma Scale < 10 or unresponsive to verbal commands), and survived at least 6 hours after arriving in the ED. Patients were excluded if a preexisting "do-not-resuscitate" order was identified, they were found to have intracranial hemorrhage, or there was clinical evidence of other severe bleeding that would exclude them from receiving TTM.

Intervention: The PACT

The PACT was comprised of an on-call physician and nurse at each PACT hospital available for consultation 24 hours per day, 7 days per week.

When the PACT was called to assist with a patient, the requesting service, usually emergency medicine, cardiology, or critical care, retained the role of most responsible service and the authority to direct care. After initial assessment and eligibility screening, the PACT nurse (RN) contacted the PACT physician (MD) for preliminary review. PACT MDs attended the bedside with the PACT RN during business hours (Monday–Friday, 9 AM to 5 PM) or suggested orders over the phone during off-hours. PACT MDs were expected to undertake a follow-up assessment of the patient at least once every 24 hours for the first 72 hours in hospital. There were four distinct PACT clinical pathways derived from the 2010 American Heart Association Emergency Cardiovascular Care and Cardiopulmonary Resuscitation Guidelines (3) and investigator consensus:

TTM. PACT assisted with TTM induction as per existing hospital cooling protocols. The target core temperature was 32–34°C.

Rapid Assessment for Percutaneous Coronary Intervention (PCI). If ST-elevation was evident on the initial electrocardiogram (ECG), the PACT MD facilitated emergent referral for coronary angiography. In the absence of ST-elevation, urgent referral for coronary angiography was facilitated if there was clinical suspicion for acute coronary syndrome in the setting of an initial shockable cardiac arrest rhythm.

Electrophysiology Assessment. The PACT MD facilitated immediate consultation with an electrophysiologist for patients experiencing rearrest or hemodynamic instability secondary to

arrhythmia. For patients who were electrically and hemodynamically stable, consultation was arranged within 1–2 days.

Appropriately Delayed Neuroprognostication. "Neuroprognostication" can include physical examination, neurophysiologic studies, imaging studies, and biochemical analyses to predict outcome after a brain insult. Neuroprognostication to predict a poor outcome (cerebral performance category, 3–5) and guide decisions on the withdrawal of life-sustaining therapy (WLST) is prone to false positives within 72 hours of cardiac arrest (18). The focus of the PACT protocol was to avoid premature WLST on the basis of neuroprognostication within 72 hours of ED arrival.

PACT notes and recommendations were written on large distinctive stickers and placed in the progress note section of the patient chart. Paper copies of the PACT master pathway were placed in the front of patient charts to serve as reminders of key care processes for primary teams.

Fourteen physicians and 33 nurses underwent 3 hours of PACT training, which included content on the purpose of PACT, the pathophysiology of postcardiac arrest syndrome, the PACT protocols, and techniques to facilitate TTM.

Data Collection

Prehospital and hospital clinical data were captured within the Rescu Epistry database, which is a composite of two precursors: The Epistry-Cardiac Arrest database of the Resuscitation Outcomes Consortium and the SPARC database (16, 19, 20). Trained personnel abstracted data from clinical records for all cardiac arrest patients within the study catchment area.

Outcomes

Primary

1) The proportion of patients who were cooled and reached less than 34°C within 6 hours of first ED arrival.
2) The proportion of patients who underwent coronary angiography within 72 hours of first ED arrival among patients "without" ST-segment elevation on their first ECG after return of spontaneous circulation. We chose this subgroup of patients as the focus of PACT intervention and the basis for the outcome measure because, at the time of study design, there was emerging evidence that acute coronary lesions were common in this subgroup, outcomes could be improved with coronary intervention (21), and an internal audit at PACT hospitals determined that emergency coronary angiography for postcardiac arrest patients with STEMI was already standard practice. The choice of a 72-hour time frame for this outcome was arbitrary and based on data availability.
3) The proportion of patients with an electrophysiologist consult before discharge among those without ST-segment elevation on their first ECG who survived at least 48 hours.
4) The proportion of patients who had WLST within 72 hours of ED arrival on the basis of neuroprognostication among those patients at risk for premature WLST. Patients who died within 72 hours of first ED arrival despite full and aggressive intensive care and those who had WLST after meeting criteria for brain death (22) were not considered "at risk" for this last outcome and were excluded from these calculations.

The goal of the PACT was to increase the proportion of patients who achieved primary outcomes 1, 2, and 3 while reducing the proportion of patients who achieved primary outcome for pathway 4 in comparison to concurrent controls.

Secondary. Secondary outcomes included survival to hospital discharge with good neurologic function (defined as a modified Rankin score of 0, 1, or 2), survival to hospital discharge, and a number of component clinical processes related to each of the primary outcomes (**Table 4**).

Analysis

We focused on comparing rates of change between intervention and control hospitals because the study intervention was expected to change behavior over time and because control and intervention hospitals had differences at baseline (**Table 1**). This approach allowed each group to act as its own control from baseline to the end of study.

The study period for the primary analysis was March 7, 2011, to February 28, 2013. We arbitrarily split the study period into eight blocks of 3-month duration for the analysis.

Patients were assigned to the intervention group if they arrived primarily at one of the PACT hospitals or were transferred to one of the PACT hospitals within 6 hours of first ED arrival. The OR for receiving a particular care practice was calculated in both groups using generalized linear mixed methods with random effects to account for clustering within centers.

TABLE 1. Characteristics of Hospitals Included in the Study, Distinguished by Comparison Group (Post-Arrest Consult Team Versus Control)

Characteristic	All	Post-Arrest Consult Team Hospitals	Control Hospitals
No. of facilities	29	2	27
Academic health science centers[a], *n* (%)	5 (17)	2 (100)	3 (11)
Staffed beds, median (range)	396 (42–1,259)	701 (450–952)	393 (42–1,259)
Percutaneous coronary intervention capable facilities, *n* (%)	5 (17)	2 (100)	3 (11)
Electrophysiology facilities, *n* (%)	3 (11)	2 (100)	1 (4)
Annual emergency department visits (mean ± SD)	65,011 ± 55,860	65,540 ± 10,448	67,649 ± 58,026

[a]As defined by the Ontario Ministry of Health and Long-Term Care (http://www.healthforceontario.ca/en/M4/Clerkship_Travel_Program/Program_Guidelines/Ontario_Academic_Health_Science_Centres).

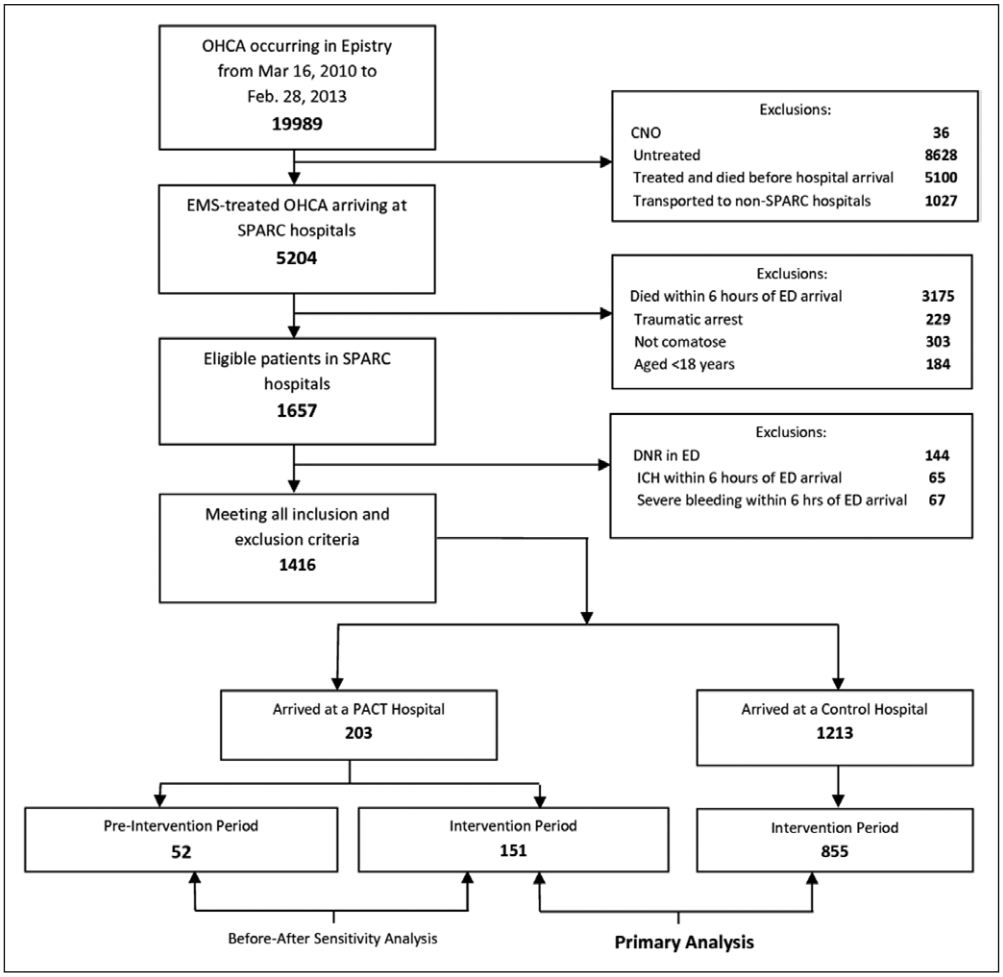

Figure 1. Consort diagram of patients considered for inclusion in the study. CNO = could not obtain the chart from medical records, DNR = do not resuscitate, ED = emergency department, EMS = emergency medical services, ICH = intracranial hemorrhage, OHCA = out-of-hospital cardiac arrest, PACT = Post-Arrest Consult Team, SPARC = Strategies for Post-Arrest Care Network.

The change in proportion of eligible patients receiving each care practice was analyzed by testing for the effects of study group, time, and the interaction between group and time. We used the interaction between group and time to estimate the ratio of the ORs for improvement over time in the intervention group versus the control group (23). These models were adjusted for age, gender, shockable initial cardiac arrest rhythm, witness status of cardiac arrest (witnessed vs unwitnessed), and bystander cardiopulmonary resuscitation (CPR).

Our primary analysis was based on the principle of intention-to-treat. We compared descriptive continuous characteristics of the study groups using the Student *t* test and the chi-square test or Fisher exact test for dichotomous variables.

We planned a priori to undertake a per-protocol sensitivity analysis that included only patients actually seen by the PACT. Also, to explore the possibility of an instantaneous change in processes associated with PACT implementation that would not be captured by our primary analysis, we undertook a before-after analysis comparing outcomes for patients seen at PACT hospitals before PACT implementation (March 16, 2010, to March 6, 2011) with those seen after PACT implementation (March 7, 2011, to February 28, 2013). We planned a sensitivity analysis restricting the comparison group to patients from PCI-capable centers.

All tests were two-sided and *p* values less than 0.05 were considered statistically significant.

Sample Size

The duration of our study and final sample size were determined by available funding.

Ethics

The research ethics boards of the participating hospitals approved this study, and the requirement for obtaining individual patient consent was waived.

RESULTS

Of the 5,204 EMS-treated OHCA patients who arrived at SPARC hospitals from March 16, 2010, to February 28, 2013, 1,006 were included in the primary analysis (**Fig. 1**). We included 151 patients who arrived at a PACT hospital and 855 patients who arrived at control hospitals. Patients brought to PACT hospitals versus control hospitals were more often men (77.5% vs 66.3%), recipients of bystander CPR (51.9% vs 39.8%), recipients of bystander automated external defibrillator use (9.3% vs 3.7%), showing ST-segment elevation on initial postarrest ECG (43.7% vs 20.6%), and in a shockable initial cardiac arrest rhythm (53.7% vs 41.5%) (**Table 2**). Of the 151 patients who arrived at PACT hospitals during the intervention period, 48 (32%) were not seen by the PACT. Reasons for missed cases included a failure of team activation (e.g., no consultation request from the receiving unit) or a lack of PACT personnel availability (e.g., occupied with another patient).

Primary Outcomes

Implementation of the PACT was associated with a significant reduction over time in WLST on the basis of neuroprognosis within 72 hours of ED arrival when compared with control patients (ratio of ORs, 0.13; 95% CI, 0.02–0.98) (**Table 3**). Compared with control, PACT was not associated

TABLE 2. Patient Characteristics

Characteristic	All, *n* (%) (*n* = 1,006)	Post-Arrest Consult Team, *n* (%) (*n* = 151)	Control, *n* (%) (*n* = 855)	*p*[a]
Age (mean ± SD)	65.2 (16.5)	64.7 (16.0)	65.3 (16.6)	0.6476
Gender (male)	684 (68.0)	117 (77.5)	567 (66.3)	0.0067
Emergency medical services witnessed	151 (15.0)	18 (11.9)	133 (15.6)	0.2489
Bystander witnessed	529 (52.6)	91 (60.3)	438 (51.2)	0.0403
Bystander cardiopulmonary resuscitation	417 (41.5)	77 (51.0)	340 (39.8)	0.0098
Bystander AED applied	46 (4.6)	14 (9.3)	32 (3.7)	0.0027
Bystander AED shocked	33 (3.3)	8 (5.3)	25 (2.9)	0.1373
No obvious cause of cardiac arrest	926 (92.1)	141 (93.4)	785 (91.8)	0.5124
Prehospital return of spontaneous circulation	873 (86.8)	132 (87.4)	741 (86.7)	0.8018
ST-segment elevation on first electrocardiogram	237 (24.1)	66 (43.7)	171 (20.6)	< 0.0001
Shockable initial rhythm[b]	430 (43.4)	80 (53.7)	350 (41.5)	0.0074
Pick-up location type				
Public	231 (23.0)	40 (26.5)	191 (22.3)	0.0786
Private	730 (72.6)	100 (66.2)	630 (73.7)	
Nursing home	45 (4.5)	11 (7.3)	34 (4.0)	

AED = automated external defibrillator.

[b]Includes documented ventricular fibrillation, pulseless ventricular tachycardia, and "shock indicated" from an automated external defibrillator.

Two-sided *p* values from Chi-squared test or Fisher exact test as appropriate.

with an increase over time of patients being treated successfully with TTM (ratio of ORs, 0.91; 95% CI, 0.31–2.65), undergoing angiography (ratio of ORs, 1.91; 95% CI, 0.17–21.04), or receiving electrophysiology consultation (ratio of ORs, 0.93; 95% CI, 0.11–8.16).

Secondary Outcomes

There were no statistically significant differences in secondary clinical process outcomes (**Table 4**) or survival outcomes (adjusted ratio of ORs for survival to hospital discharge, 0.98; 95% CI, 0.25–3.12 and survival with good neurologic status, 0.75; 95% CI, 0.19–2.94) for patients seen at PACT hospitals versus control hospitals.

Sensitivity and Subgroup Analyses

Outcomes in the PACT hospitals before and after the implementation of PACT did not differ in direction from those of the primary analysis. Similarly, the per-protocol sensitivity analysis including only those patients actually assessed by the PACT team did not yield materially different results. Because the results of our primary analysis did not demonstrate a difference between the intervention and control groups with respect to angiography and electrophysiology assessment, a planned subgroup analysis using only centers with these on-site services was abandoned.

Discussion

Implementation of an interdisciplinary postcardiac arrest consult team to operationalize standardized postcardiac arrest care was associated with reduced premature WLST but was not associated with improvements in other important aspects of postarrest care.

WLST immediately precedes death in the majority of fatal cases in the ICU (24). Neuroprognostication to identify patients who will have poor outcomes is inaccurate within 72 hours after cardiac arrest and has the potential to result in the premature death of patients who might have recovered with continued support (25, 26). Our results suggest that a PACT, emphasizing appropriately delayed neuroprognostication, may be an effective knowledge translation strategy to address this problem. We did not measure a survival benefit from reduced premature WLST, but our study was underpowered for survival outcomes.

However, PACT did not improve the number of eligible patients receiving successful TTM, angiography within 72 hours of hospital arrival, or electrophysiology assessment. Our results contrast with those from several other studies. For example, Rittenberger et al (27) report increasing TTM usage over time in a single academic center after implementation of a physician-based, on-call postcardiac arrest service. This service differed from the PACT in that it was comprised of a small number of physicians only and responded

TABLE 3. Patients Achieving Primary Process Outcomes Over Time in the Post-Arrest Consult Team Group Versus Control Group

Process Outcome	Post-Arrest Consult Team		Control		Adjusted[a] Ratio of ORs (95% CI) Across All Eight Time Periods
	Study Time Period		Study Time Period		
	First, *n* (%)	Last, *n* (%)	First, *n* (%)	Last, *n* (%)	
Targeted temperature management					
Target reached within 6 hr of ED arrival	14/18 (77.8)	17/26 (65.4)	44/130 (33.8)	40/105 (38.1)	0.91 (0.31–2.65) *n* = 992
Assessment for acute coronary syndrome					
Angiogram < 72 hr from ED arrival among patients without STE	2/15 (13.3)	2/9 (22.2)	9/83 (10.8)	5/83 (6.0)	1.91 (0.17–21.04) *n* = 717
Neuroprognostication					
Withdrawal of life-sustaining therapy within 72 hr after ED arrival on the basis of neuroprognostication[b]	4/15 (26.7)	0/22 (0)	17/104 (16.3)	15 /89 (16.9)	0.13 (0.02–0.98) *n* = 822
Electrophysiology					
Patients without STE surviving > 48 hr after ED arrival with electrophysiologist consult before discharge	4/13 (30.8)	2/5 (40.0)	5/61 (8.2)	4/68 (5.9)	0.93 (0.11–8.16) *n* = 538

ED = emergency department, OR = odds ratio, STE = ST-segment elevation.

[a]Adjusted for patient age, gender, shockable initial cardiac arrest rhythm, witness status of cardiac arrest (witnessed vs unwitnessed), bystander cardiopulmonary resuscitation, and the clustering of patients within hospital.

[b]Patients who died within 72 hr of first emergency department arrival despite full and aggressive intensive care and those who had life-sustaining therapy withdrawn after meeting criteria for brain death were not considered "at risk" for this outcome and were excluded from these calculations.

Numbers are shown for the first and last 3-mo time blocks of the study period. The ratios of odds ratios (ORs) were generated using data from all eight time blocks and reflect relative changes over time between the Post-Arrest Consult Team and control groups. Ratio of ORs (95% CIs) that do not include 1 indicate statistical significance.

to patients after in-hospital cardiac arrest and OHCA. They report a marked increase in TTM use from 3% in 2005 to 55% in 2007 after the team was implemented. In our study, the baseline proportion of patients receiving TTM was 100% in PACT hospitals and 75.4% in control hospitals, highlighting an important difference in baseline conditions. Deal et al (28) report an improvement in successful TTM from 64% to 96% after implementation of ED cardiac arrest response team (eCART) in a single academic center ED. The eCART investigators were unable to demonstrate increased usage of coronary angiography or an increase in survival associated with team implementation. In both of these before-after studies, it is difficult to know how much of the observed improvements can be attributed to the intervention as opposed to secular trends unrelated to the intervention.

There are several potential explanations for why we were able to demonstrate an improvement in the neuroprognostication process but not others. The neuroprognostication process may have been easier to implement because of a relatively longer time window to affect decision-making processes in the ICU, interaction with colleagues in the same specialty peer group to achieve this goal (most of the PACT physicians were intensive care physicians), and it involved no additional diagnostic or therapeutic maneuvers.

There may have been a ceiling effect at play with respect to the TTM process goals. All patients in the intervention group had TTM attempted and 77.8% reached temperature target within 6 hours during the first time block.

The failure of PACT to effect change in rates of coronary angiography for postarrest patients may reflect the uncertainty in clinical benefit among interventional cardiologists who may have existed during the study period. Despite recent American Heart Association guidelines that recommend emergency coronary angiography for postarrest patients with ST-elevation and suggest that it is reasonable for patients without ST-segment elevation, there is a lack of high-quality data to support routine use (29). Even if PACT changed attitudes toward the need for angiograms, electrophysiology assessments, and somatosensory-evoked potentials, resource limitations may have been too great to overcome. Finally, without full authority over patient care as

TABLE 4. Patients Achieving Secondary Process Outcomes Over Time in the Post-Arrest Consult Team Group Versus Control Group

Process Outcome	Post-Arrest Consult Team		Control		Adjusted[a] Ratio of ORs (95% CI) Across All Eight Time Periods
	Study Time Period		Study Time Period		
	First, *n* (%)	Last, *n* (%)	First, *n* (%)	Last, *n* (%)	
Targeted temperature management					
Cooling attempted in eligible patients	18/18 (100)	22/26 (84.6)	98/130 (75.4)	87/105 (82.9)	0.29 (0.05–1.78) *n* = 992
Target reached at any time	18/18 (100)	22/26 (84.6)	93/130 (71.5)	82/105 (78.1)	0.53 (0.11–2.55) *n* = 992
Assessment for acute coronary syndrome					
Angiogram within 90 min of emergency department arrival among patients with STE on initial electrocardiogram	2/3 (66.7)	11/17 (64.7)	6/17 (26.1)	11/22 (50)	0.11 (0.01–1.27) *n* = 226
Neuroprognostication					
Withdrawal of life-sustaining therapy within 72 hr (any reason)	4/18 (22.2)	6/26 (23.1)	30/130 (23.1)	19/105 (18.1)	1.89 (0.53–6.67) *n* = 992
CT or MRI in patients with coma at 72 hr	8/9 (88.9)	11/14 (78.6)	48/51 (94.1)	37/49 (75.5)	1.97 (0.22–7.79) *n* = 434
Somatosensory-evoked potentials in patients with coma at 72 hr	0/9 (0)	3/14 (21.4)	0/51 (0)	2/49 (4.1)	0.13 (0.01–2.83) *n* = 434
Electrophysiology					
Implantable cardiac defibrillator in patients alive > 48 hr without STE	1/12 (7.7)	1/5 (20)	4/61 (6.6)	5/68 (7.3)	2.23 (0.23–21.66) *n* = 534

OR = odds ratio, STE = ST-segment elevation.

[a]Adjusted for patient age, gender, shockable initial cardiac arrest rhythm, witness status of cardiac arrest (witnessed vs unwitnessed), bystander cardiopulmonary resuscitation, and the clustering of patients within hospital.

a consulting service, PACT recommendations might have been inconsistently translated into actual changes to patient care.

Our study has several limitations. The generalizability of our results must be considered in the context of the SPARC Network, which was formed in 2007 with the objective of improving postcardiac arrest care processes. Participating institutions may be more motivated or different in other ways compared with nonparticipating institutions. However, SPARC hospitals were diverse including urban, suburban, and rural hospitals as well as academic and nonacademic facilities. This was an observational study, and it is therefore possible that differences due to PACT implementation were related to unadjusted differences in case mix or hospital care practices unrelated to the PACT. Our study may have been underpowered to detect clinically important differences between groups.

CONCLUSION

The implementation of a multidisciplinary postcardiac arrest consult team was associated with a reduction in WLST on the basis of neuroprognosis within 72 hours after OHCA. However, the PACT did not increase rates of successful TTM, coronary angiography, formal electrophysiology assessments, or functional survival for comatose patients admitted to hospital after OHCA.

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