Title

Trends, Predictors and Outcomes After Utilization of Targeted Temperature Management in Cardiac Arrest Patients With Anoxic Brain Injury

Journal

The American Journal of the Medical Sciences, 360(4)

ISSN

0002-9629

Authors

Khan, Muhammad Zia
Khan, Muhammad U
Patel, Kinjan
et al.

Publication Date

2020-10-01

DOI

10.1016/j.amjms.2020.05.025

Peer reviewed

HHS Public Access
Author manuscript
Am J Med Sci. Author manuscript; available in PMC 2021 October 01.

Published in final edited form as:
Am J Med Sci. 2020 October ; 360(4): 363–371. doi:10.1016/j.amjms.2020.05.025.

Trends, Predictors and Outcomes After Utilization of Targeted Temperature Management in Cardiac Arrest Patients With Anoxic Brain Injury

Muhammad Zia Khan, MD[1], **Muhammad U. Khan, MD**[1], **Kinjan Patel, MD**[2], **Safi U. Khan, MD**[1], **Shahul Valavoor, MD**[1], **Mohammed Osman, MD**[2], **Sudarshan Balla, MD**[2], **Muhammad Bilal Munir, MD**[2,3]

[1]Department of Medicine, West Virginia University, Morgantown, West Virginia

[2]Division of Cardiovascular Medicine, West Virginia University Heart & Vascular Institute, Morgantown, West Virginia

[3]Section of Electrophysiology, Division of Cardiology, University of California San Diego, La Jolla, California

Abstract

Background: Targeted Temperature Management (TTM) is a class I recommendation for the management of sudden cardiac arrest (SCA) patients with presumed brain injury. We aimed to study trends, predictors and outcomes in SCA patients from a nationally represented US population sample.

Methods: We utilized the National Inpatient Sample from years 2005 to 2014 for the purpose of our study. Patients with SCA and anoxic brain injury were selected using relevant ICD-9 codes. Data were analyzed for trends over the years and key outcomes were assessed. Logistic regression analysis was done to determine predictors of TTM utilization in our study population.

Results: A total of 78,465 patients with SCA and anoxic brain injury were identified from January 2005 to December 2014. Out of these, approximately 4,481 (5.7%) patients underwent TTM. Patients that underwent TTM were younger compared to patients without TTM utilization (60.67 vs. 63.27 years, $P < 0.01$). African Americans, Hispanics and women were less likely to undergo TTM. Myocardial infarction, electrolyte disorders and cardiogenic shock were associated with higher odds of TTM utilization. Sepsis, renal failure and diabetes were associated with underutilization of TTM. Inpatient mortality was higher in patients who did not undergo TTM when compared to patients who underwent TTM (67.30% vs. 65.10%, $P < 0.01$).

Conclusions: Although TTM utilization increased over our study period, the overall application of TTM was still dismal. Factors that circumvent TTM utilization need to be addressed in future studies so more eligible patients could benefit from this life saving therapy.

Correspondence: Muhammad Bilal Munir, MD, West Virginia University Heart & Vascular Institute, 1 Medical Center Drive, Morgantown, West Virginia 26505. (muhamad.munir@hsc.wvu.edu).

SUPPLEMENTARY MATERIALS
Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjms.2020.05.025.

Disclosures: None

Keywords

Cardiac arrest; National trends; Targeted temperature management; Mortality; Disparities

INTRODUCTION

Nearly 500,000 episodes of sudden cardiac arrest (SCA) occur annually in the United States in both inpatient and outpatient settings. SCA carries very high mortality and neurocognitive disability.[1] Interventions such as high-quality chest compressions and immediate application of defibrillation therapy in cases of shockable rhythm have been found to increase the likelihood of achieving return of spontaneous circulation (ROSC) with resultant better survival and neurological recovery.[2,3] However, few therapeutic modalities have been shown to improve outcomes in the post-ROSC phase. Targeted Temperature Management (TTM) has been established as a standard of care in treatment of SCA patients who are presumed to have concomitant neurological injury. Several studies done in the past 2 decades have shown improved outcomes in post-SCA comatose patients in whom TTM was applied in the post-ROSC phase.[4–7] To highlight the importance of TTM in the management of SCA patients with brain injury, the American Heart Association (AHA) has given a Class I indication to the utilization of this therapeutic modality.[8]

Despite these strong recommendations, there is no national data on utilization of TTM in post SCA comatose patients. Additionally, there is limited real life data on the outcomes after use of TTM in eligible SCA patients, as most of our insight into the matter comes from controlled clinical studies. We, therefore, aimed to study these parameters using a nationally representative US population.

METHODS

Data were derived from National Inpatient Sample (NIS). NIS is part of the Healthcare Cost and Utilization Project (HCUP) databases and is made possible by a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality. The NIS is derived from all states and represents more than 97% of the US population.[9] NIS allows national estimates of healthcare utilization, costs and outcomes. Since NIS is compiled annually, the data can be used for analysis of disease trends over time. Institutional Review Board approval and informed consents were not required for this study given the de-identified nature of the NIS database and public availability.

We analyzed NIS data from January 2005 to December 2014 using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes. Patients ≥ 18 years were included. Patients with SCA were identified by ICD-9 codes of 427.41, 427.42 and 427.5 in all diagnosis fields. Patient with missing age or other missing demographics were excluded. A total of 369,835 patients were identified in this way. ICD-9 code for anoxic brain injury (348.1) was used to further specify our study population. The ICD-9 procedure code 99.81 was used in all procedures fields to identify patients undergoing TTM. Selected Agency for Healthcare Research and Quality comorbidities were generated as binary variables for analysis. ICD-9 diagnosis and procedural codes were used to identify patients undergoing left heart catheterization, need for percutaneous coronary intervention, thrombolysis therapy and other procedures (Tables 1 and 2). Baseline characteristics and hospital outcomes for patients were derived and compared among TTM and non-TTM groups. Patient population was further stratified based on shockable or nonshockable etiology of SCA. Key hospital outcomes and resource utilization were again assessed based on the underlying rhythm for SCA. For the purpose of our current study, we did not analyze outcomes based on location of SCA (in-hospital vs. out of hospital). Please see Figure 1 for flow chart.

To account for potential confounding factors and selection bias, a propensity score-matching model was developed using logistic regression to derive 2 matched groups for comparative outcomes analysis. A nearest neighbor 1:1 variable ratio, parallel, balanced propensity-matching model was made using a caliper width of 0.2. Descriptive statistics were presented as frequencies with percentages for categorical variables and as means with standard deviations for continuous variables. Baseline characteristics were compared using a Pearson χ^2 test and Fisher's exact test for categorical variables and independent samples *t* test for continuous variables.

Logistic regression was performed to estimate odds ratios (ORs) with 95% confidence intervals (CIs) to determine predictors for patient undergoing TTM after SCA. Initially, binomial logistic regression model was used to identify variables from demographic data (Table 1) that were significantly associated with patients undergoing TTM (P value < 0.10). These variables were then subsequently utilized in a multiple logistic regression model to identify predictors of TTM application (forward conditional stepwise probabilities selection model for multiple logistic regression; P value <0.10). A type I error rate of <0.05 was considered statistically significant. All statistical analyses were performed using statistical package for social science (SPSS) version 24 (IBM Corp) and R 3.6.

RESULTS

A total of 78,465 patients with SCA and anoxic brain injury were identified from January 2005 to December 2014. Of these, 4,481 (5.7%) patients underwent TTM treatment. Baseline characteristics of the study population are shown in Table 1. Mean age was 63.12 years (SD, 16.08 years). 42.8% patients were women. 65.7% were Caucasian, 18.3% were African American and 8.9% were Hispanics. Crude mortality was 67.2% (52,697). Mortality was higher in patients not undergoing TTM (67.3%) as compared to patients undergoing TTM (65.1%) (Table 2). Of patients undergoing TTM, 28.3% underwent left heart catheterization as compared to 14.3% for patient not undergoing TTM. Of patients undergoing TTM, 12.2% had PCI as compared to 6.8% not undergoing TTM (Table 2). Baseline characteristics after propensity score matching are shown in supplementary Table 2. Over the years there has been increased trend in TTM utilization (Figure 2). This increased trend is more or less same across the gender, though TTM was utilized more in males when compared to females over our study period. Hospital outcomes and resource utilization based on underlying rhythm for SCA are shown in Table 3. There was increased utilization of TTM in patients in whom SCA was due to shockable rhythm (8.6%) when compared to patients in which the cause of SCA was deemed to be a non-shockable rhythm

(4.2%). Significant improvement in mortality was noted in patients who have evidence of alternating shockable and nonshockable rhythm during SCA, provided TTM was utilized in that cohort (53.4% vs. 55.4%, $P < 0.01$). Mortality was worse in SCA patients with a nonshockable rhythm with utilization of TTM (75.2% vs. 72.1%, $P < 0.01$).

Predictors for TTM utilization are shown in Figure 3. Patients with advanced age and female gender were less likely to receive TTM. African American and Hispanic patients had lower utilization of TTM. Higher income group, urban and large hospitals were associated with higher odds of undergoing TTM. Patients with septic shock, congestive heart failure, renal failure, paralyses, solid and metastatic cancer were less likely to undergo TTM, while patients with myocardial infarction, cardiogenic shock, obesity and electrolyte abnormalities had higher odds of undergoing TTM.

Asian and Caucasian patients had higher utilization of TTM over the years. The mean cost of stay was higher for patients undergoing TTM. Over the years the mean cost of stay increased for both patients undergoing TTM and not undergoing TTM (Figure 4).

DISCUSSION

The main findings of our current investigation are: (1) TTM is still underutilized in SCA patients with concomitant neurological injury, as only 5.7% of patients in our study cohort benefitted from this potentially lifesaving therapy. (2) There has been an increased trend of TTM utilization over our study period although its adoption rate was still significantly low over the years. (3) Mortality continues to be higher in patients in whom TTM was not utilized after an SCA event when compared to patients who underwent TTM. Moreover, patients in which TTM was utilized tend to have better discharge outcomes and shorter length of stay when compared to patients without TTM application. (4) Disparities were noted with respect to demographics in utilization of TTM after SCA with brain injury. Female gender and certain ethnic minorities (African Americans and Hispanics) were less likely to receive TTM. On the other hand certain co-morbidities such as myocardial infarction (MI), electrolyte abnormalities and cardiogenic shock were associated with increased incidence of TTM utilization.

The primary determinant of immediate and long-term neurological outcomes after SCA seems to be hypoxic ischemic brain injury.[10] The clinical presentations of these patients are highly variable, ranging from mild cognitive impairment to persistent vegetative state[11] and largely depends on how effectively and promptly post SCA resuscitation measures are established.[2,3] TTM is the only proven post ROSC modality that has shown to improve outcomes in SCA patients who have minimal neurological response after a SCA event.[4–7] Our study has shown marked under-utilization of this potentially lifesaving therapy in SCA patients who have presumed brain injury. Although over our study period, there has been a gradual increase in application of TTM to this patient population, the overall percentage of potentially eligible patients who could derive greatest benefit from TTM therapy continued to be low (Figure 1). Several factors could be responsible for such low utility of TTM seen in our national cohort. The studies depicting strong clinical benefit from TTM in SCA survivors were done in early 2000 with the first national guideline on the subject issued in

2010[12] with subsequent update in 2015.[8] It is speculated that health care systems may not have established protocols such as postarrest care team or cooling practices until these guidelines came into effect. Our study did show gradual increase in utilization of TTM after year 2010; however, the increased trend is still dismal compared to previous years. The current finding necessitates holistic establishment of protocols by health care systems such as establishment of postarrest teams that have experience in management of these patients, which would increase TTM utilization in eligible patients. Indeed, such interventions have been shown to improve outcomes in these patients after an indexed SCA event.[13]

Our study has shown female gender and certain ethnic minorities such as African Americans and Hispanics to be associated with reduced incidence of TTM utilization. The disparate care with respect to these specific demographics has been studied before, both specifically in the context of SCA and generally with respect to other health care delivery. In a study by Groeneveld et al.[14] on approximately 5,948 Medicare patients who survived SCA, the utilization of secondary prevention implantable cardioverter defibrillator (ICD) implantation was significantly lower in the African American population compared to the white population. Additionally, this trend of low ICD implantation translated into worse long-term survival in African American patients in their cohort. Similarly, a study by Hernandez et al.[15] on more than 13,000 advanced heart failure patients with indication for primary prevention ICD showed reduced incidence of such implants in African American and female patients. Our own study of a nationally represented US population sample of more than 170,000 patients showed that African Americans are at a disadvantage when it comes to secondary prevention ICD implantation after SCA episode.[16] Studies have shown that these disparities exist with respect to health care delivery even when certain confounding variables such as income and insurance status and severity of condition are balanced.[17] Our dataset, unfortunately, is not designed to delve into potential mechanisms responsible for this disparate care and should be a subject of future investigations in this realm.

In our study cohort, MI, electrolyte disorders and cardiogenic shock were associated with higher odds of TTM utilization. SCA associated with these modalities usually results in initial shockable rhythm such as ventricular tachycardia and/or ventricular fibrillation. Earlier studies have shown improved outcomes with utilization of TTM protocol if initial rhythm was shockable[4,5] and that explains increased utilization of this therapeutic modality in these subgroups. Moreover, patients with renal disease and sepsis tend to have low utilization of TTM in our cohort likely related to induction of coagulopathy with TTM utilization with resulting poor outcomes.[18] These associations are mere speculations on our part and needs further investigation in future studies.

The present study has limitations to be considered. NIS is an administrative claim-based database that uses ICD-9-CM codes for diagnosis that may be subject to error. The hard clinical points such as SCA and TTM utilization are, however, less prone to error. NIS collects data on in-patient discharges and each admission is registered as an independent event. It is therefore possible that 1 patient may have more than 1 admission in the same or subsequent years. NIS samples are not designed to follow patients longitudinally so long-term outcomes could not be assessed in the present study. Additionally the circumstances of pre-ROSC phase that affect outcomes such as bystander cardiopulmonary resuscitation, emergency personal contact with the patient, time to administer vasoactive drugs and downtime before the start of cardiopulmonary resuscitation could not be examined from present dataset. Additionally, for the purpose of this study, we have sampled all SCA patients regardless of in-hospital or out-of-hospital arrest. It could be speculated that in-hospital SCA may have better TTM utilization and clumping all patients into 1 category may have skewed the results. However, a study from Get With the Guidelines-Resuscitation registry showed a similar low rate of TTM utilization in patients who suffered in-hospital SCA.[19] We, therefore, believe that such stratification may not have affected our results and in fact given a more inclusive overview of TTM utilization in post-ROSC SCA patients.

CONCLUSIONS

We found low utilization of TTM in SCA patients with anoxic brain injury. We also found a steady but slow upward trend of TTM application over our study years. Gender and racial disparities were also noted with respect to TTM utilization. Mortality continues to be high if TTM was not applied in SCA patients post-ROSC.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding:

None.

REFERENCES

1. Holzer M Targeted temperature management for comatose survivors of cardiac arrest. N Engl J Med. 2010;363(13):1256–1264. 10.1056/NEJMct1002402. [PubMed: 20860507]
2. Hansen CM, Kragholm K, Granger CB, et al. The role of bystanders, first responders, and emergency medical service providers in timely defibrillation and related outcomes after out-of-hospital cardiac arrest: results from a statewide registry. Resuscitation. 2015;96:303–309. [PubMed: 26386371]
3. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med. 2015;372:2307–2315. [PubMed: 26061835]
4. The Hypothermia after Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med. 2002;346:549–556. [PubMed: 11856793]
5. Bernard SA, Gray TW, Buist MD, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N Engl J Med. 2002;346:557–563. [PubMed: 11856794]
6. Nielsen N, Wetterslev J, Cronberg T, et al. Targeted temperature management at 33°C versus 36°C after cardiac arrest. N Engl J Med. 2013;369:2197–2206. [PubMed: 24237006]
7. Kirkegaard H, Søreide E, de Haas I, et al. Targeted temperature management for 48 vs 24 hours and neurologic outcome after out-of-hospital cardiac arrest: a randomized clinical trial. JAMA. 2017;318:341–350. [PubMed: 28742911]
8. Callaway CW, Donnino MW, Fink EL, et al. Post-cardiac arrest care: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132: S465–S482. [PubMed: 26472996]

9. Agency for Healthcare Research and Quality. Overview of the National (Nationwide) Inpatient Sample (NIS). Rockville: AHRQ; 2019 Available at: https://www.hcup-us.ahrq.gov/nisoverview.jsp#about. Accessed 16 June 2020.
10. Laver S, Farrow C, Turner D, et al. Mode of death after admission to an intensive care unit following cardiac arrest. Intensive Care Med. 2004;30:2126–2128. [PubMed: 15365608]
11. Nolan JP, Neumar RW, Adrie C, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. Resuscitation. 2008;79:350–379. [PubMed: 18963350]
12. Morrison LJ, Deakin CD, Morley PT, et al. Part 8: advanced life support: 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation. 2010;122(suppl 2):S345–S421. [PubMed: 20956256]
13. Dainty KN, Racz E, Morrison LJ, et al. Implementation of a post-arrest care team: understanding the nuances of a team-based intervention. Implement Sci. 2016;11:112. [PubMed: 27491427]
14. Groeneveld PW, Heidenreich PA, Garber AM. Racial disparity in cardiac procedures and mortality among long-term survivors of cardiac arrest. Circulation. 2003;108:286–291. [PubMed: 12835222]
15. Hernandez AF, Fonarow GC, Liang L, et al. Sex and racial differences in the use of implantable cardioverter-defibrillators among patients hospitalized with heart failure. JAMA. 2007;298:1525–1532. [PubMed: 17911497]
16. Munir MB, Alqahtani F, Aljohani S, et al. Trends and predictors of implantable cardioverter defibrillator implantation after sudden cardiac arrest: insight from the national inpatient sample. Pacing Clin Electrophysiol. 2018;41:229–237. [PubMed: 29318626]
17. Nelson A Unequal treatment: confronting racial and ethnic disparities in health care. J Natl Med Assoc. 2002;94:666–668. [PubMed: 12152921]
18. Chun-Lin H, Jie W, Xiao-Xing L, et al. Effects of therapeutic hypothermia on coagulopathy and microcirculation after cardiopulmonary resuscitation in rabbits. Am J Emerg Med. 2011;29:1103–1110. [PubMed: 20951524]
19. Chan PS, Berg RA, Tang Y, et al. Association between therapeutic hypothermia and survival after in-hospital cardiac arrest. JAMA. 2016;316: 1375–1382. [PubMed: 27701659]

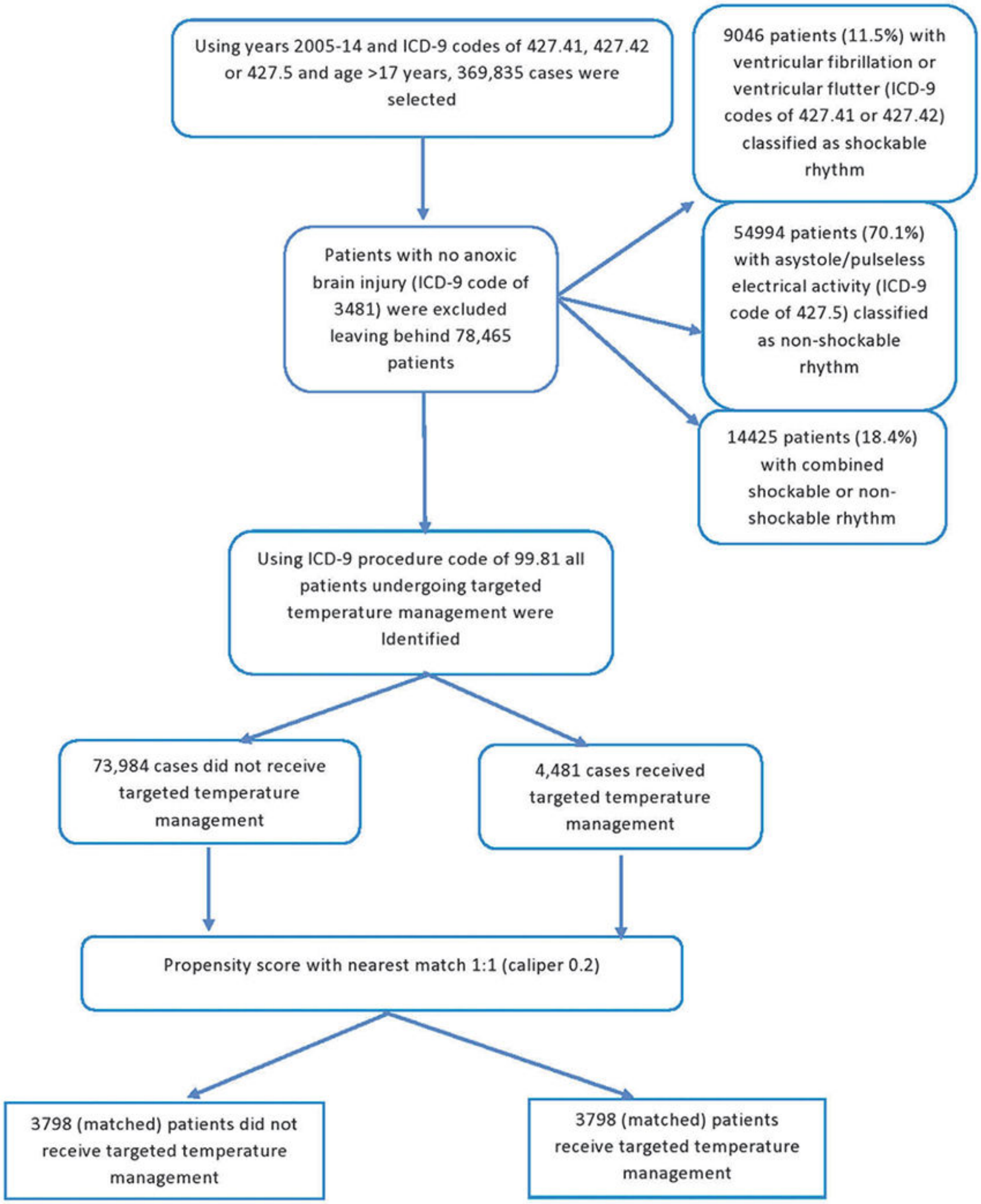

FIGURE 1.
Flow chart of case selection.

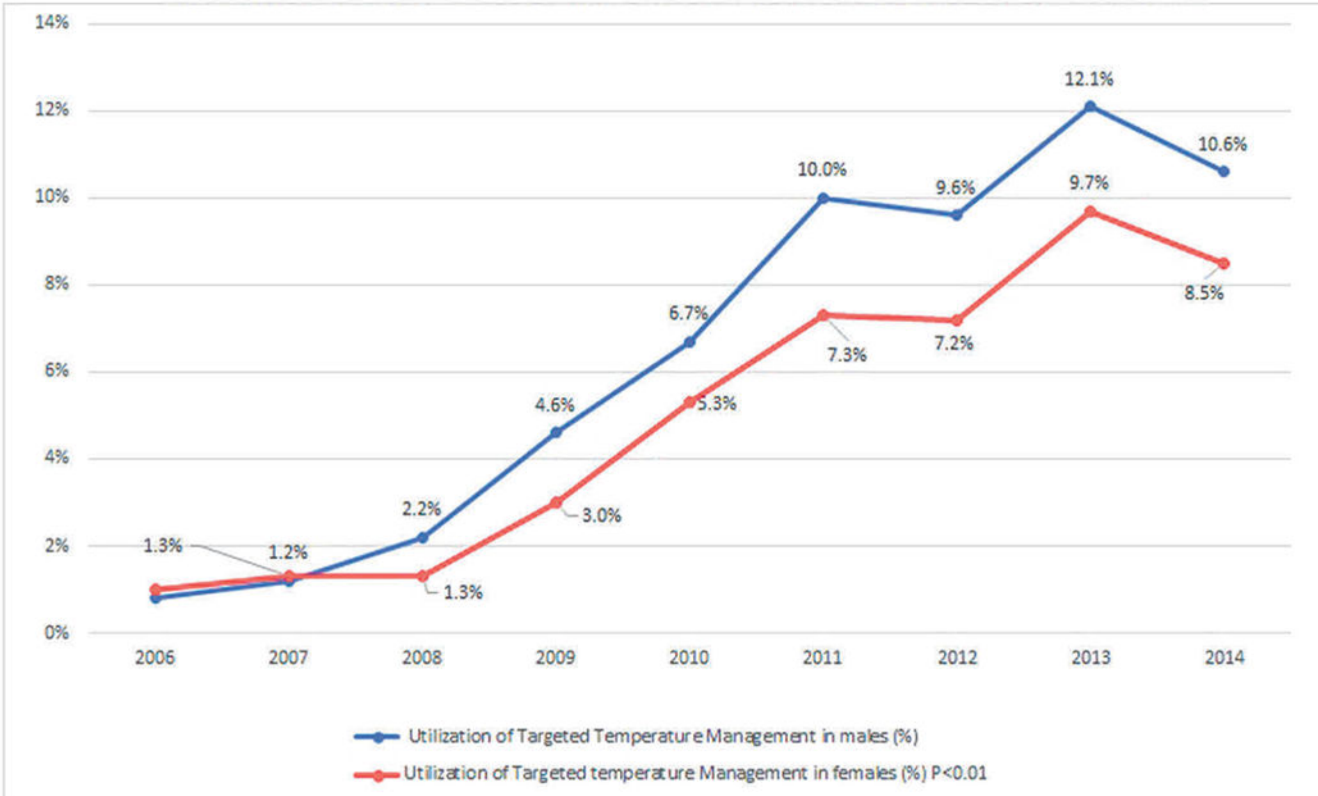

FIGURE 2.

Trends of hypothermia protocol utilization over our study period, the trend is further characterized based on gender.

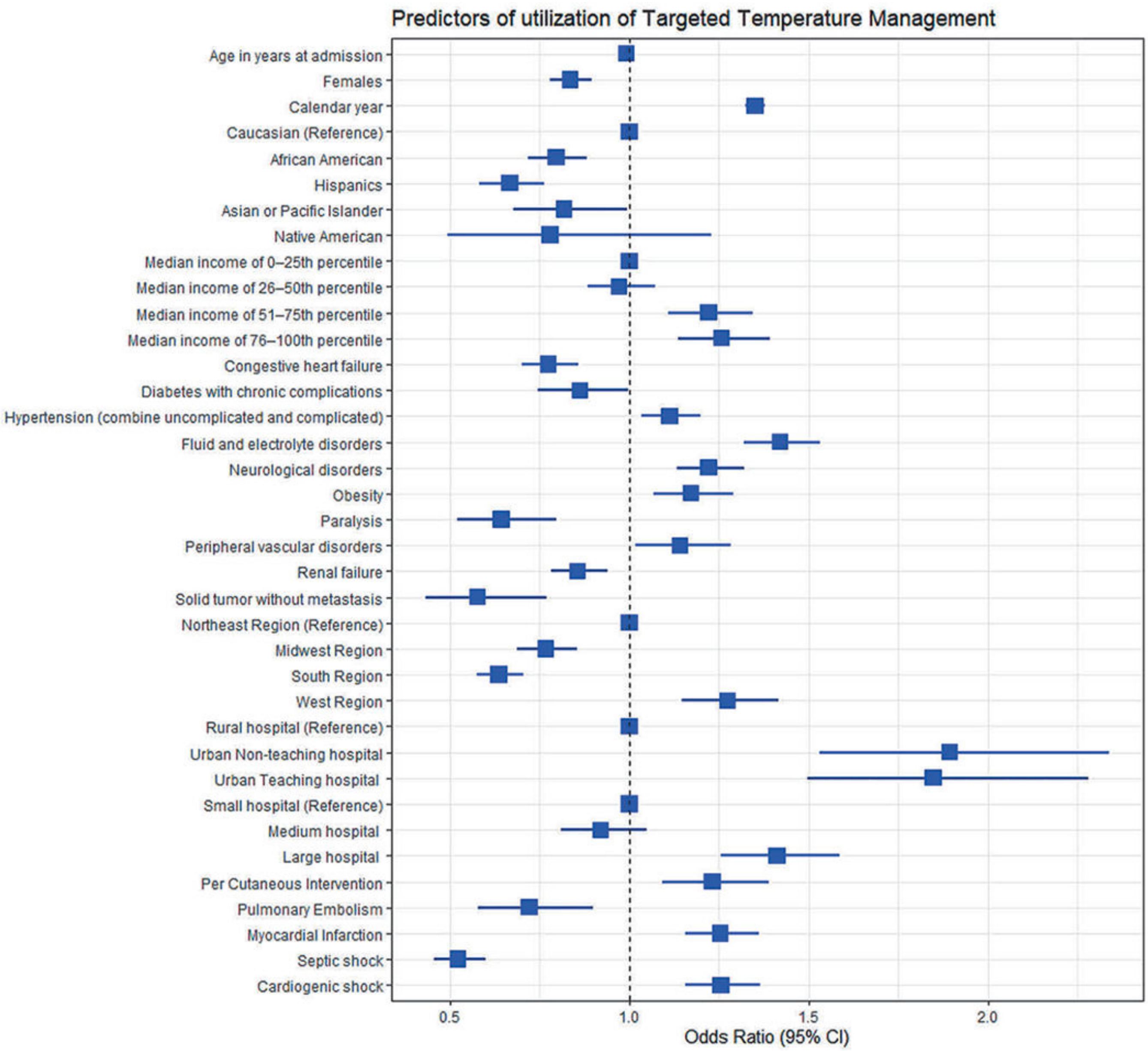

FIGURE 3.

Predictors of hypothermia protocol utilization.

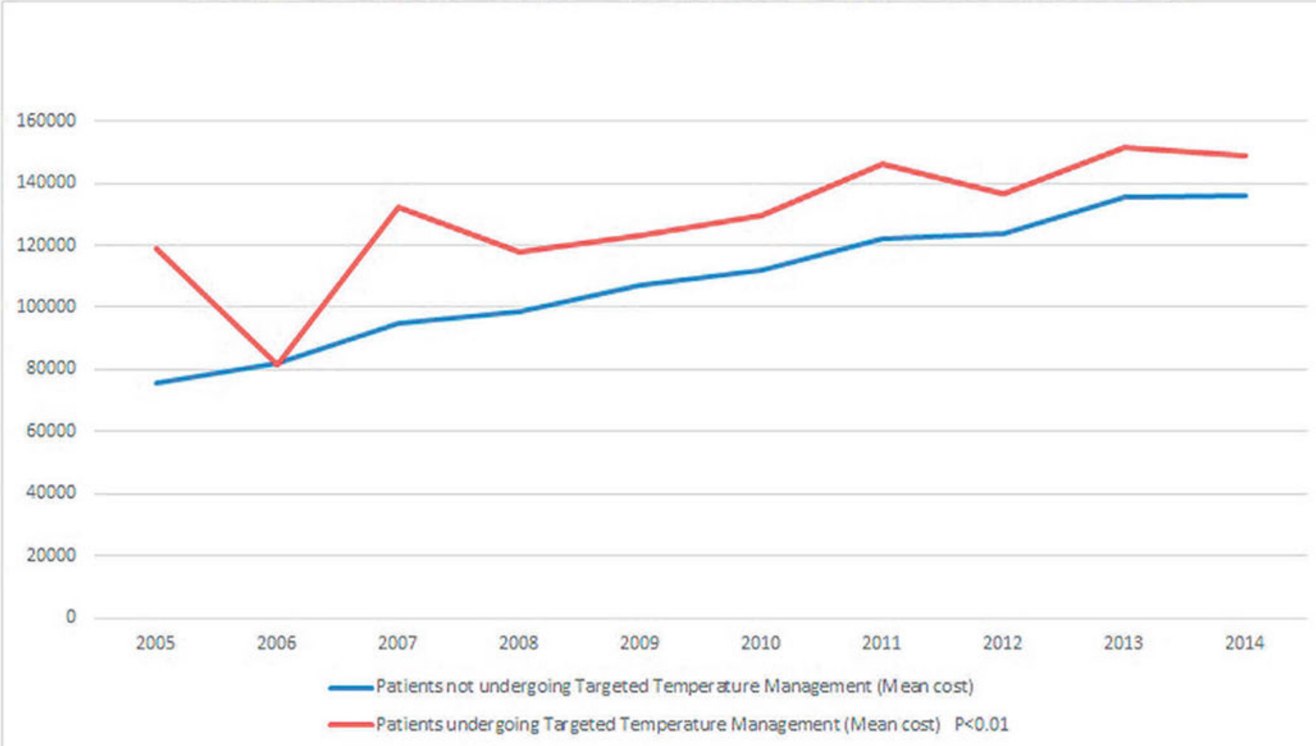

FIGURE 4.
Mean cost of hospitalization over our study period.

TABLE 1.

Baseline characteristics of the study population.

Baseline characteristics	All SCA[a] patients (n = 78,465)	SCA patients not undergoing TTM[b] (n = 73,984)	SCA patients undergoing TTM[b] (n = 4,481)	*P* Value
Age (mean [SD]) years	63.12 (16.08)	63.27 (16.1)	60.67 (15.4)	<0.01
Female no. (%)	33,580 (42.80)	31,954 (43.20)	1,626 (36.30)	<0.01
Race no. (%)				
Caucasian	44,569 (65.70)	41,698 (65.30)	2,871 (71.80)	<0.01
African American	12,377 (18.30)	11,810 (18.50)	567 (14.20)	
Hispanics	6,066 (8.90)	5,791 (9.10)	275 (6.90)	
Asian or Pacific Islander	2,035 (3.00)	1,899 (3.00)	136 (3.40)	
Native American	462 (0.70)	438 (0.70)	24 (0.60)	
Medical comorbidity no. (%)				
Anemia (chronic blood loss)	828 (1.10)	786 (1.10)	42 (0.90)	0.42
Anemia (deficiency anemias)	16,004 (20.40)	15,005 (20.30)	999 (22.30)	<0.01
Collagen vascular diseases	1,389 (1.80)	1,309 (1.80)	80 (1.80)	0.93
Congestive heart failure	13,856 (17.70)	13,292 (18.00)	564 (12.60)	<0.01
Chronic pulmonary disease	19,540 (24.90)	18,460 (25.00)	1,080 (24.10)	0.2
Coagulopathy	9,668 (12.30)	8,951 (12.10)	717 (16.00)	<0.01
Diabetes, uncomplicated	19,730 (25.10)	18,595 (25.10)	1,135 (25.30)	0.77
Diabetes with chronic complications	5,384 (6.90)	5,121 (6.90)	263 (5.90)	<0.01
Drug abuse	4,764 (6.10)	4,402 (5.90)	362 (8.10)	<0.01
Hypertension (combine uncomplicated and complicated)	41,047 (52.30)	38,566 (52.10)	2,481 (55.40)	<0.01
Liver disease	2,569 (3.30)	2,424 (3.30)	145 (3.20)	0.82
Lymphoma	530 (0.70)	506 (0.70)	24 (0.50)	0.24
Fluid and electrolyte disorders	45,281 (57.70)	42,155 (57.00)	3,126 (69.80)	0.03
Metastatic cancer	1,503 (1.90)	1,436 (1.90)	67 (1.50)	<0.01
Other neurological disorders	17,102 (21.80)	15,955 (21.60)	1,147 (25.60)	<0.01
Obesity	9,307 (11.90)	8,613 (11.60)	694 (15.50)	<0.01
Peripheral vascular disorders	6,272 (8.00)	5,868 (7.90)	404 (9.00)	<0.01

Baseline characteristics	All SCA[a] patients (n = 78,465)	SCA patients not undergoing TTM[b] (n = 73,984)	SCA patients undergoing TTM[b] (n = 4,481)	*P* Value
Pulmonary circulation disorders	3,106 (4.00)	2,955 (4.00)	151 (3.40)	0.03
Renal failure	17,945 (22.90)	17,081 (23.10)	864 (19.30)	<0.01
Solid tumor without metastasis	1,768 (2.30)	1,713 (2.30)	55 (1.20)	<0.01
Valvular disease	3,363 (4.30)	3,192 (4.30)	171 (3.80)	0.11
Associated diagnosis				
Acute myocardial infraction	22,211 (28.30)	20,684 (28.00)	1,527 (34.10)	<0.01
Acute pulmonary embolism	2,283 (2.90)	2,178 (2.90)	105 (2.30)	0.02
Cardiogenic shock	12,161 (15.50)	11,058 (14.90)	1,103 (24.60)	<0.01
Septic shock	7,013 (8.90)	6,748 (9.10)	265 (5.90)	<0.01
Shock (not otherwise specified)	3,982 (5.10)	3,689 (5.00)	293 (6.50)	<0.01
Hospital control and or funding				
Government or Private	30,774 (39.20)	29,608 (40.00)	1,166 (26.00)	<0.01
Government, nonfederal	5,931 (7.60)	5,611 (7.60)	320 (7.10)	
Private, not-for-profit	29,950 (38.20)	27,459 (37.10)	2,491 (55.60)	
Private, investor-owned	10,649 (13.60)	10,175 (13.80)	474 (10.60)	
Private, either not-for-profit or investor-owned	1,161 (1.50)	1,131 (1.50)	30 (0.70)	
Hospital location				
Rural	5,256 (6.70)	5,107 (6.90)	149 (3.30)	<0.01
Urban nonteaching	34,346 (43.80)	32,547 (44.00)	1,799 (40.10)	
Urban teaching	38,863 (49.50)	36,330 (49.10)	2,533 (56.50)	
Bed size of the hospital				
Small	8,007 (10.20)	7,590 (10.30)	417 (9.30)	<0.01
Medium	19,849 (25.30)	18,894 (25.50)	955 (21.30)	
Large	50,609 (64.50)	47,500 (64.20)	3,109 (69.40)	
Primary payer				
Medicare	43,158 (55.10)	41,023 (55.60)	2,135 (47.70)	<0.01
Medicaid	9,595 (12.30)	9,015 (12.20)	580 (13.00)	
Private insurance	17,556 (22.40)	16,318 (22.10)	1,238 (27.70)	

Baseline characteristics	**All SCA[a] patients (n = 78,465)**	**SCA patients not undergoing TTM[b] (n = 73,984)**	**SCA patients undergoing TTM[b] (n = 4,481)**	***P* Value**
Self-pay	5,114 (6.50)	4,785 (6.50)	329 (7.40)	
No charge	384 (0.50)	364 (0.50)	20 (0.40)	
Other	2,492 (3.20)	2,319 (3.10)	173 (3.90)	
Region				
Northeast	11,797 (15.00)	10,997 (14.90)	800 (17.90)	<0.01
Midwest	17,698 (22.60)	16,644 (22.50)	1,054 (23.50)	
South	31,974 (40.70)	30,688 (41.50)	1,286 (28.70)	
West	16,996 (21.70)	15,655 (21.20)	1,341 (29.90)	
Median household income no. (%)				
0–25th percentile	23,613 (30.90)	22,518 (31.20)	1,095 (25.10)	<0.01
26–50th percentile	19,891 (26.00)	18,891 (26.20)	1,000 (22.90)	
51–75th percentile	18,136 (23.70)	16,936 (23.50)	1,200 (27.50)	
76–100th percentile	14,856 (19.40)	13,787 (19.10)	1,069 (24.50)	

[a]Sudden cardiac arrest.

[b]Targeted temperature management.

TABLE 2.

Hospital encounter outcomes and resource utilization of the study cohort.

Hospital outcomes, No. (%)	All SCA[a] patients	SCA[a] patients not undergoing TTM[b]	SCA[a] patients undergoing TTM[b]	*P* Value
Died at discharge	52,697 (67.20)	49,781 (67.30)	2,916 (65.10)	<0.01
Discharge disposition of surviving patients, No. (%)				
Routine/self-care	4,698 (18.2)	4,289 (17.70)	409 (26.10)	<0.01
Short-term hospital	3,215 (12.5)	3,016 (12.50)	199 (12.70)	
Another type of facility	15,093 (58.6)	14,312 (59.10)	781 (49.90)	
Home Health Care	2,351 (9.1)	2,202 (9.10)	149 (9.50)	
Resource utilization, Mean (SD)				
Length of stay, mean (SD), days	9.34 (15.06)	9.38 (15.30)	8.61 (10.31)	<0.01
Cost of hospitalization-mean (SD), $	112,278 (151,952)	110,529 (152,549)	140,909 (138,748)	<0.01
Procedures during stay, No. (%)				
Pericardiocentesis	231 (0.30)	221 (0.30)	10 (0.20)	<0.36
Left heart catheterization	11,838 (15.1)	10,570 (14.3)	1,268 (28.3)	<0.01
Percutaneous intervention	5,572 (7.10)	5,024 (6.80)	548 (12.20)	<0.01
Thrombolytic therapy	725 (0.90)	674 (0.90)	51 (1.10)	<0.01
Ventilator	71,304 (90.90)	66,975 (90.50)	4,329 (96.60)	<0.01
Gastrostomy	6,481 (8.30)	6,229 (8.40)	252 (5.60)	<0.01
Tracheostomy	7,672 (9.80)	7,366 (10.00)	306 (6.80)	<0.01

[a] Sudden cardiac arrest.

[b] Targeted temperature management.

TABLE 3.

Hospital encounter outcomes and resource utilization based on type of rhythm.

Hospital outcomes, no. (%)	Patients with shockable rhythm (n = 9,046)			Patients with nonshockable rhythm (n = 54,994)			Patients with both rhythms (n = 14,425)		*P* Value
	Patients not undergoing TTM[a] (n = 8,266)	Patients undergoing TTM[a] (n = 780)	*P* Value	Patients not undergoing TTM[a] (n = 52,652)	Patients undergoing TTM[a] (n = 2,342)	*P* Value	Patients not undergoing TTM[a] (n = 13,066)	Patients undergoing TTM[a] (n = 1,359)	
Died at discharge	4,568 (55.3)	428 (54.9)	0.834	37,969 (72.1)	1,762 (75.2)	<0.01	7,244 (55.4)	726 (53.4)	<0.01
Discharge disposition of surviving patients, No. (%)									
Routine/self-care	1,056 (12.8)	111 (14.2)	0.77	1,784 (3.4)	88 (3.8)	<0.01	1,449 (11.1)	210 (15.5)	<0.01
Short-term hospital	443 (5.4)	37 (4.7)		1,731 (3.3)	77 (3.3)		842 (6.4)	85 (6.3)	
Another type of facility	1,745 (21.1)	160 (20.5)		9,703 (18.4)	357 (15.2)		2,864 (21.9)	264 (19.4)	
Home Health Care	416 (5.0)	38 (4.9)		1,208 (2.3)	47 (2.0)		578 (4.4)	64 (4.7)	
Resource utilization, Mean (SD)									
Length of stay, mean (SD), days	10.54 (15.9)	9.86 (10.8)	<0.01	9.29 (15.8)	7.92 (10.6)		9.05 (12.4)	9.06 (9.3)	<0.01
Cost of hospitalization-mean (SD), $	134,453 (161,033)	168,136 (134,134)	<0.01	104,371 (152,920)	126,566 (136,885)		120,296 (143,313)	150,057 (141,482)	<0.01
Procedures during stay, No. (%)									
Pericardiocentesis	24 (0.3)	<11	0.95	161 (0.3)	<11		36 (0.3)	<11	0.38
Thrombolytic therapy	76 (0.9)	<11	0.10	479 (0.9)	25 (1.1)	0.43	119 (0.9)	19 (1.4)	0.07
Percutaneous intervention	1,312 (15.9)	141 (18.1)	<0.01	1,638 (3.1)	142 (6.1)	<0.01	2,074 (15.9)	265 (19.5)	<0.01
Left heart catheterization	2,617 (31.7)	356 (45.6)	<0.01	3,848 (7.3)	305 (13.0)	<0.01	4,105 (31.4)	607 (44.7)	<0.01
Ventilator	6,915 (83.7)	746 (95.6)	<0.01	48,468 (92.1)	2,289 (97.7)	<0.01	11,592 (88.7)	1,294 (95.2)	<0.01
Gastrostomy	638 (7.7)	42 (5.4)	0.018	4,725 (9.0)	156 (6.7)	<0.01	866 (6.6)	54 (4.0)	<0.01

Hospital outcomes, no. (%)	Patients with shockable rhythm (n = 9,046)			Patients with nonshockable rhythm (n = 54,994)			Patients with both rhythms (n = 14,425)		*P* Value
	Patients not undergoing TTM[a] (n = 8,266)	**Patients undergoing TTM[a] (n = 780)**	***P* Value**	**Patients not undergoing TTM[a] (n = 52,652)**	**Patients undergoing TTM[a] (n = 2,342)**	***P* Value**	**Patients not undergoing TTM[a] (n = 13,066)**	**Patients undergoing TTM[a] (n = 1,359)**	
Tracheostomy	71 (0.9)	<11	<0.01	1,028 (2.0)	35 (1.5)	0.12	63 (0.5)	<11	<0.01

[a]Targeted temperature management.