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Original paper

The prevalence of sustained electrical capture during prehospital transcutaneous pacing: a multicenter observational study

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Abstract

Introduction: Transcutaneous pacing (TCP) is used to treat bradycardia with hemodynamic compromise. Prior data suggested that electrical capture was uncommon during prehospital TCP. We aimed to determine the prevalence of sustained electrical capture and identify associated factors in a multicenter cohort.

Methods: Four emergency medical services agencies contributed patients who received TCP from 2017 to 2024. Data were abstracted from electronic health records and cardiac monitor files. Sustained electrical capture was defined as a wide QRS complex with a T-wave after each pacer impulse for at least 90% of a 60 second period, followed by electrical capture for 90% of the remainder of the TCP attempt. Multivariable logistic regression modeling was used to estimate the association between variables of interest and sustained electrical capture.

Results: Of 299 patients, 29 (9.7%) had sustained electrical capture. Our cohort was a median 73 [62, 82] years of age, 48.5% ($n = 145$) female, and 33.8% ($n = 101$) had post-ROSC TCP. The median body weight was 78.3 [68–95.3] kilograms, pre-TCP heart rate was 38 [30, 45] beats per minute (bpm) and maximum TCP current was 90 [70–110] mA. Lower weight (aOR: 0.95 [0.93, 0.98] per kg; $n = 208$), lower pre-TCP heart rate (aOR: 0.96 [0.93, 0.99] per bpm; $n = 297$), and higher delivered current (aOR: 1.25 [1.08, 1.45] per 10 mA; $n = 208$) were associated with higher odds of sustained electrical capture.

Conclusions: We found that sustained electrical capture during prehospital TCP was uncommon and associated with pre-TCP heart rate, pacing current, and body weight.

Keywords: Transcutaneous pacing, Bradycardia, Electrical capture, Mechanical capture, Bradyasystole

Introduction

Transcutaneous pacing (TCP) is used to treat patients with bradycardia and hemodynamic compromise in the prehospital setting,^{1,2} and maintains a Class IIb recommendation from the American Heart Association for this indication. Clinicians are trained to increase the current delivered by pacemaker devices until ‘electrical capture,’ or the presence of a QRS complex and T wave, is observed on continuous ECG. Then, ‘mechanical capture,’ or the confirmation of cardiac

contraction, is often assessed by pulse palpation.^{3–5} This therapy is frequently used during post-resuscitation care, and one nationwide study suggested that 35% of all patients who received prehospital transcutaneous pacing received this therapy following resuscitation from cardiac arrest.¹

Prior data suggest that patients who receive prehospital TCP are at high risk of morbidity and mortality.¹ One factor that may contribute to the high prevalence of deterioration following attempted TCP is ‘false electrical capture.’⁶ Electrical artifact from pacer discharge may mimic the morphology of a QRS and cause clinicians

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to mistakenly think that electrical capture has been achieved.^{6,7} One single center study demonstrated that the majority of patients who received prehospital TCP did not exhibit sustained electrical capture despite clinician-reported mechanical capture.⁶

Our primary aim was to calculate the prevalence of sustained electrical capture in a multicenter cohort of patients who received TCP in the prehospital setting. Secondly, we aimed to identify factors associated with sustained electrical capture and characterize the outcomes of patients who received prehospital TCP.

Methods

Study design and setting

We performed a retrospective review of TCP attempts between March 2017 and October 2024 from four urban emergency medical services (EMS) agencies in the United States. One site previously contributed patients to a single center study of transcutaneous pacing,⁶ but all data were abstracted independently for this investigation. Treatment was provided by clinicians capable of delivering autonomous advanced life support, including the administration of medications and advanced airway management. All patients in this study were treated by EMS clinicians trained in ECG interpretation and had the ability to remotely consult with physicians to aid in treatment decisions.

Participants

We identified eligible patients via query within the agency's electronic health record (EHR) software (emsCharts [ZOLL Medical Corporation, Chelmsford, MA], HealthEMS [Sansio, Duluth, MN], ImageTrend [Eagan, MN], TripTix [Digitech, Chappaqua, NY]), and software that collected annotated biosignal data from cardiac monitor/defibrillator files (RescueNet CaseReview [ZOLL Medical Corporation, Chelmsford, MA] or CODESTAT [Stryker, Redmond, WA]). All patients were treated with either a ZOLL X Series (ZOLL Medical Corporation, Chelmsford, MA) or LIFEPAK 15 (Stryker, Redmond, WA) cardiac monitor/defibrillator.

We included all patients with ≥ 60 consecutive seconds of TCP after excluding patients who did not have a cardiac monitor file available for review, never had the pacer turned on, or were receiving CPR when TCP was initiated.

Outcome measures

Our primary outcome was sustained electrical capture as defined by the presence of a wide QRS complex and T wave with each pacer impulse for at least 90% of any 60 second period and continuing for at least 90% of the interval between the start of the first qualifying 60 second period and the time the monitor was turned off or CPR was initiated. Review of continuous ECG and trans-thoracic impedance data was facilitated by CODE-STAT review software for all patients treated with a LIFEPAK 15 cardiac monitor, and RescueNet CaseReview for all patients treated with a ZOLL X-Series cardiac monitor. A representative example of electrical capture is displayed in Fig. 1, and representative sections of ECG from all cases with sustained electrical capture are displayed in the Supplemental Material (Section 2.0). Intermittent electrical capture was defined as electrical capture sustained for 25–89% of any 60 second interval. Non-sustained electrical capture was defined as electrical capture sustained for at least 90% of any 60 second period but not sustained until the monitor was turned off or CPR was initiated.

Prior to beginning abstraction of variables related to electrical capture, a randomly selected subset of 30 cases was reviewed by all abstractors to establish inter-rater reliability using Fleiss' kappa. A random number generator (random.org) with an upper limit set at the number of enrolled cases was used to select the IRR cohort. Assessments of interrater reliability for our outcomes of interest are included in the Supplemental Material (Section 3.0).

We defined appropriate TCP discontinuation as all of the following: (1) no sustained electrical capture, (2) maximum current setting reached for the cardiac monitor model, (3) no mechanical capture reported by the EMS clinician, and (4) TCP discontinuation within 5 min of the maximum current time. The purpose of this variable was to identify if EMS clinicians recognized that TCP was not successful and abandoned the procedure outside the context of post-TCP cardiac arrest.

We collected survival to hospital discharge and survival with a favorable neurological outcome (Cerebral Performance Category [CPC] of 1 or 2) as secondary outcomes. Patients who had termination of resuscitation in the field were classified as dying prior to hospital discharge.

Variables and data sources

Some patients received multiple TCP attempts between periods of CPR. We abstracted data from only the first attempt at TCP for this study. Patient demographics, prehospital treatments, electrotherapy pad position, clinician-reported mechanical capture, and outcome data were collected by agency personnel using a standardized RED-Cap template.^{8,9} (Supplemental Material (Section 1.0)) Clinician-reported mechanical capture was defined as mechanical capture documented in the prehospital EHR.

A single member of the study team (TS) abstracted additional data elements from the cardiac monitor/defibrillator devices used to treat patients including vital signs and TCP timing, current, and rate. We defined the post-TCP prehospital care interval as the interval between the time of TCP initiation and the end of the biosignal data recorded by the monitor/defibrillator.

The pre-TCP heart rate was calculated from the 30 seconds of continuous ECG prior to the 'pacer on' time. If 30 seconds of interpretable ECG was not available, the rate was derived from a minimum of 10 seconds prior to TCP initiation. Pulse oximetry values were only documented if a physiologic plethysmograph wave was present in order to prevent the inclusion of artifactual pulse oximetry readings. Both pre- and post-TCP vital signs were documented. The last vital sign value documented prior to TCP initiation was used for the pre-TCP value. The first blood pressure or SpO₂ value documented following the time of set current was recorded as the post-TCP blood pressure. The post-TCP ETCO₂ was the first value recorded at least 60 seconds following the set current.

The full data dictionary is included in the Supplemental Material (Section 1.0).

Ethics

The use of these data for research purposes received institutional review board approval (protocol ref. 2404969713). The hypotheses, strategy for data collection, and analysis plan were pre-registered using the Open Science Framework (https://osf.io/chd7u/?view_only=641c65b91e7a47e396c9f89770f83148). Deviations from our prespecified analysis plan due to missingness and other sources of bias are described in the Supplemental Material (Section 5.0).

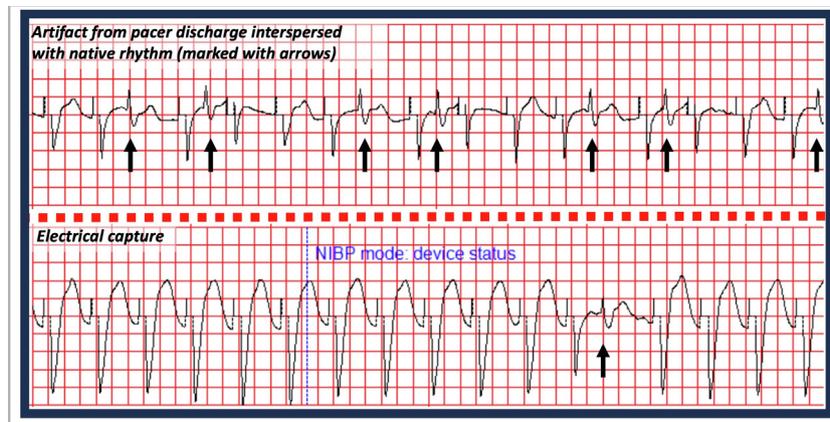


Fig. 1 – Example of electrical capture.

This image is an example of the progression from 'false capture' to electrical capture. The top panel displays pacer artifact interspersed with the underlying bradycardic rhythm. The bottom panel displays electrical capture that was achieved after an increase in the TCP current to 130 mA.

Statistical methods

Descriptive statistics were used to evaluate the study sample. Continuous variables were reported as medians with interquartile ranges and categorical variables as percentages with frequencies. Binomial exact 95% confidence intervals were reported for each definition of electrical capture. Because patients who received post-ROSC pacing may differ from the overall cohort in terms of both physiology and prognosis, we performed a subgroup analysis stratified by whether TCP was initiated post-ROSC. An a priori sample size calculation was not performed, and the size of our cohort was determined by the number of EMS agencies our team was able to recruit, and the number of eligible patients treated by each agency during the study period. A post-hoc sample size calculation suggested that recruitment of 283 patients would be sufficient to estimate the true prevalence of sustained electrical capture assuming the true prevalence was 10% (precision = 3.5%, 95% confidence level).¹⁰

We used multivariable logistic regression modeling to investigate the association between maximum current and sustained electrical capture, adjusting for monitor model and body weight. We also used a multivariable logistic regression model to identify associations between body weight and sustained electrical capture (controlling for maximum current, monitor model, and patient sex) and between pre-TCP heart rate and sustained electrical capture (controlling for post-ROSC TCP and pre-pacing medication). Firth's correction¹¹ was used due to the limited number of primary outcome events in our cohort. A simulation study demonstrated that this method reduces bias, including for models with a low event per variable ratio.¹² Direct acyclic graphs (DAGs) were used to inform the multivariable modeling strategy.¹³ (Supplemental Material (Section 4.0)) DAGs are used to illustrate the hypothesized relationships between exposures, outcomes, and variables that serve as confounders, mediators, or colliders. Use of DAGs to guide multivariable modeling allows avoidance of self-inflicted biases caused by adjustment for colliders or mediators and allows derivation of the minimal adjustment sets required to mitigate bias from confounding variables. Because the effect estimates associated with each covariable in a multivariable regression model should not be interpreted as causal effects, particularly in the context of models designed to evaluate a single exposure-outcome relationship (Table 2 Fallacy), we did not report the odds ratios and confidence intervals associated with the covariables in our regression model that were not the primary expo-

sure of interest.¹⁴ Results were reported as adjusted odds ratios (aOR) and 95% confidence intervals (95% CI). Stata/SE 18 (Stata-Corp, College Station, TX) was used for all analyses.

Results

Patient and treatment characteristics

Overall, we screened 387 patients for eligibility, and after application of exclusion criteria, 299 were included in the analyses (Fig. 2). The median age was 73 [62, 82] years, 48.5% ($n = 145$) of patients were female, the median body weight was 78.3 [68–95.3] kilograms (kg), and 32.4% ($n = 97$) of patients were White, non-Hispanic. Post-ROSC TCP was performed in 33.8% ($n = 101$) of the cohort.

The median pre-TCP heart rate was 38 [30, 45] beats per minute (bpm), and the median individual maximum TCP current was 90 [70–110] milliamps (mA). The median patient had 13.6 [6.1, 26.3] minutes of post-TCP prehospital care, and the cohort contributed a total of 87.4 hours of post-TCP biosignal data. Additional characteristics of the enrolled cohort are displayed in Tables 1 and 2.

Only 10 (3.3%) patients received the maximum current possible using the cardiac monitor/defibrillator (eight patients treated with ZOLL X Series, maximum current 140 mA; two patients treated with LIFEPAK 15, maximum current 200 mA), of whom 8 did not have sustained electrical capture. Only 2/270 patients (0.7%) without sustained electrical capture met the criteria for appropriate TCP discontinuation.

Overall, 41.5% ($n = 124$) patients received post-TCP CPR. Termination of resuscitation in the field occurred for 3.0% ($n = 9$) of the cohort. Among the 79.3% ($n = 237$) patients with outcome data available, 37.1% ($n = 88$) survived to hospital discharge. Of the 65 patients who survived to hospital discharge and had a CPC score, 60% ($n = 39$) had a favorable neurologic outcome (Table 3).

Outcomes

Prevalence of electrical capture

Overall, 9.7% [6.6, 13.6] ($n = 29$) had sustained electrical capture, 6.4% [3.9, 9.7] ($n = 19$) had non-sustained electrical capture, and 9.0% [6.0, 12.9] ($n = 27$) had intermittent electrical capture. The majority of our cohort (224/299, 74.9% [69.6, 79.7]) had no electrical capture observed.

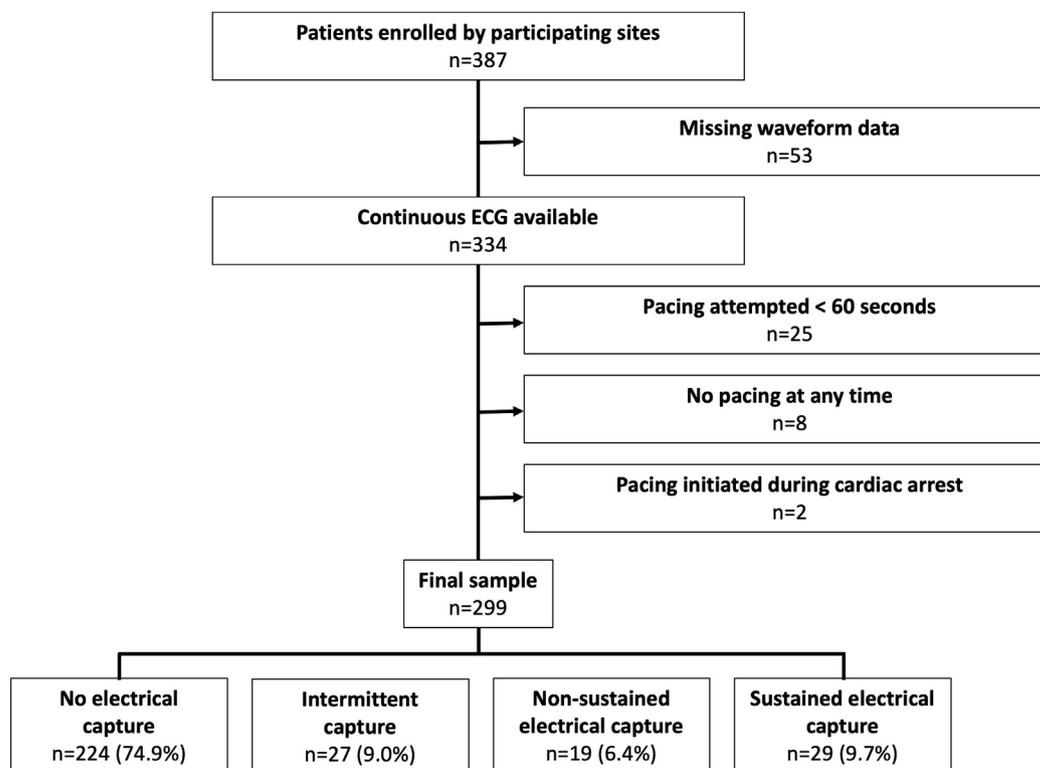


Fig. 2 – Flow diagram detailing derivation of cohort.

ECG = electrocardiogram. ROSC = return of spontaneous circulation.

The proportion of patients who achieved sustained electrical capture was similar among patients with and without post-ROSC TCP initiation (7.9% [3.5, 15.0]) vs. 10.6% [6.7, 15.8]) (Supplemental Material (Section 7.0)).

Sustained electrical capture occurred at a median of 32 [14, 167] seconds after pacing initiation and continued until the end of the pre-hospital period of care.

Factors associated with electrical capture

Multivariable logistic regression modeling with Firth's correction suggested that increased maximum current (aOR: 1.25 [1.08, 1.45] per 10 mA; $n = 208$), lower body weight (aOR: 0.95 [0.92, 0.98] per kg; $n = 208$), and lower pre-TCP heart rate (aOR: 0.96 [0.93, 0.99], $n = 297$) were associated with higher odds of sustained electrical capture (Table 4). Varying sample sizes reflect missing data for the covariables included in each model.

Clinician documented mechanical capture and sustained electrical capture

EMS clinicians documented mechanical capture for 170 (56.9%) patients. Of these patients, only 17 (10%) had sustained electrical capture and 124 (72.9%) had no electrical capture observed (Supplemental Material (Section 6.0)).

Discussion

In this multicenter cohort study, sustained electrical capture during prehospital TCP was uncommon (9.7%) and approximately 75% of patients had no observed electrical capture despite clinician docu-

mentation of mechanical capture in more than half of the included cases. These findings corroborate a prior single-center study⁶ that found that less than one in five patients who received prehospital TCP had evidence of sustained electrical capture on ECG despite all having reported mechanical capture.

We identified several factors associated with sustained electrical capture, including lower weight, lower pre-TCP heart rate, and higher TCP current. Patients with a lower body weight may have decreased transthoracic impedance, which could increase the current that reaches the myocardium and facilitate electrical capture. This hypothesis is supported by our observation that higher delivered 'set' and maximum currents were also associated with sustained electrical capture. The mechanism driving the association between higher pre-TCP heart rates and the absence of sustained electrical capture is less clear. It is possible that patients with higher pre-TCP heart rates may have been suffering from different pathophysiology than patients with lower heart rates or patients with higher pre-TCP heart rates may have been more likely to experience spontaneous increases in heart rate above the demand pacing threshold, which would decrease the amount of time patients were eligible to be classified as experiencing sustained electrical capture. This may have been due to the underlying etiology of bradycardia, correction of reversible causes, or administration of chronotropic medications.

Detecting mechanical capture via pulse palpation is a common method for confirming successful TCP.^{3,4} In our study, a majority of the patients without any electrical capture had clinician-reported mechanical capture in the EHR. Given that electrical capture is a prerequisite for mechanical capture, this finding suggests that reliance on pulse palpation to confirm successful TCP may be prone to error,

Table 1 – Pre/peri-TCP initiation cohort characteristics.

	No sustained electrical capture	Sustained electrical capture	Total
<i>N</i>	270 (90.3%)	29 (9.7%)	299 (100.0%)
Age (years)	72.5 (62.0–82.0)	77.0 (65.0–84.0)	73.0 (62.0–82.0)
Weight (kilograms) <i>missing: 91</i>	81.6 (70.2–96.0) <i>missing: 85</i>	63.5 (49.9–77.1) <i>missing: 6</i>	78.3 (68.0–95.3)
Sex			
Male	139 (51.5%)	15 (51.7%)	154 (51.5%)
Female	131 (48.5%)	14 (48.3%)	145 (48.5%)
Race/ethnicity			
Black	127 (47.0%)	14 (48.3%)	141 (47.2%)
White	89 (33.0%)	8 (27.6%)	97 (32.4%)
Asian	20 (7.4%)	4 (13.8%)	24 (8.0%)
Hispanic	13 (4.8%)	1 (3.4%)	14 (4.7%)
Native Hawaiian/Pacific Islander	2 (0.7%)	1 (3.4%)	3 (1.0%)
Unknown	19 (7.0%)	1 (3.4%)	20 (6.7%)
Post-ROSC TCP			
No	177 (65.6%)	21 (72.4%)	198 (66.2%)
Yes	93 (34.4%)	8 (27.6%)	101 (33.8%)
Initial GCS <i>missing: 54</i>	3.0 (3.0–13.0) <i>missing: 48</i>	7.0 (3.0–14.0) <i>missing: 6</i>	4.0 (3.0–13.0)
Pre TCP SBP <i>missing: 116</i>	96.0 (76.0–126.0) <i>missing: 103</i>	86.0 (74.5–104.0) <i>missing: 13</i>	95.0 (76.0–124.0)
Pre TCP SpO ₂ <i>missing: 206</i>	97.0 (91.5–99.5) <i>missing: 182</i>	96.0 (90.0–98.0) <i>missing: 24</i>	97.0 (91.0–99.0)
Pre TCP HR <i>missing: 2</i>	39.0 (30.0–46.0) <i>missing: 2</i>	33.0 (24.0–42.0) <i>missing: 0</i>	38.0 (30.0–45.0)
Pre TCP ETCO ₂ <i>missing: 171</i>	27.0 (19.0–42.0) <i>missing: 155</i>	20.0 (14.0–38.0) <i>missing: 16</i>	26.5 (18.0–42.0)
Pre-TCP atropine			
No	225 (83.3%)	23 (79.3%)	248 (82.9%)
Yes	45 (16.7%)	6 (20.7%)	51 (17.1%)
Pre-TCP vasopressor			
No	244 (90.4%)	26 (89.7%)	270 (90.3%)
Yes	26 (9.6%)	3 (10.3%)	29 (9.7%)

(continued on next page)

Table 1 (continued)

	No sustained electrical capture	Sustained electrical capture	Total
Pad position			
Anterior/Posterior (AP)	6 (2.2%)	1 (3.4%)	7 (2.3%)
Anterior/Lateral (AL)	11 (4.1%)	1 (3.4%)	12 (4.0%)
Unknown	253 (93.7%)	27 (93.1%)	280 (93.6%)
Initial current (mA)	52.5 (30.0–75.0)	65.0 (40.0–80.0)	55.0 (30.0–75.0)
Initial pacing rate	80.0 (70.0–80.0)	80.0 (70.0–80.0)	80.0 (70.0–80.0)

This table describes the baseline characteristics of patients stratified by the presence of sustained electrical capture. GCS = Glasgow Coma Scale, SBP = systolic blood pressure, bpm = beats per minute, TCP = transcutaneous pacing, ETCO₂ = end tidal carbon dioxide, mA = milliamperes, vasopressor = epinephrine, norepinephrine, dopamine, phenylephrine.

which mirrors prior data suggesting that pulse palpation during cardiac arrest is unreliable.^{15,16} Pulse palpation is even more complicated in patients with ongoing TCP, due to both pacemaker-induced muscle contractions and the underlying bradycardic pulse rate. Compounding the limitations of pulse palpation, the presence of electrical capture cannot be used independently to identify mechanical capture. Studies of TCP for bradycardic cardiac arrest that enrolled patients in the prehospital setting reported that the probability of mechanical capture (palpable pulses) among patients who achieved electrical capture ranged from 11.8% to 33.3%.^{17–19} The use of point-of-care ultrasound (POCUS) to confirm cardiac contractility at a pacemaker-synchronized rate may improve the ability of EMS clinicians to identify mechanical capture.^{20,21}

It may also be warranted to test modifications to the TCP procedure based on our findings. For example, starting at a higher initial current as a default could increase electrical capture prevalence, and may also be warranted as a direct extrapolation from the original clinical trial by Hedges et al. which started at 200 mA.²² Our data suggest that it may be common practice for EMS clinicians to start at low currents and stop increasing the current before maximum device settings are reached, even if electrical capture is not achieved. Only 10 patients across the entire cohort received the maximum current possible, which is a concerning finding given that TCP often fails to obtain mechanical capture even at maximum available currents.²³ This could be due to clinician misinterpretation of electrical artifact as electrical capture and resulting incorrect clinician belief that transcutaneous pacing was effective at the set current.

To our knowledge, this is the largest study to date of electrical capture during TCP and is the only multi-center study of TCP that incorporated standardized review of continuous ECG data. Our study highlights the importance of utilizing continuous waveform data from cardiac monitors to study the care provided to critically ill patients in the prehospital setting. In addition, we employed both inter-rater reliability evaluation and consensus review to ensure the reproducibility of our findings.

Limitations

Our study is subject to all the limitations of retrospective, observational studies, including the potential influence of residual confounding and unknown or unmeasured confounders. Due to our limited sample size and high missingness for several important variables,

such as body weight and pre-pacing vital signs, our statistical models also have important limitations that impair our ability to completely model exposure-outcome relationships.

We used directed acyclic graphs to derive the minimally sufficient adjustment sets for our multivariable logistic regression models, and applied Firth's correction to mitigate bias from the low event per variable ratios observed. Despite these efforts to minimize bias, unknown or unmeasured confounders may be responsible for the associations observed.

Our analysis of interrater reliability with Fleiss' kappa was performed after enrollment of <25% of our cohort as a pragmatic step to determine feasibility and is significantly limited by the low number of outcome events observed in the randomly selected sample. To further address the validity of our classification schema, we also described our agreement with expert reviewers and included ECG images from every patient classified as experiencing sustained capture in the [Supplemental Material](#).

We excluded patients who received TCP for less than 60 seconds and patients who did not have continuous electrocardiogram data available. Patients who received less than 60 seconds of TCP likely represent a heterogeneous cohort of patients with resolution of bradycardia or rapid progression to cardiac arrest. In addition, we felt that it was implausible for clinicians to be able to appropriately titrate current, observe electrical capture, and confirm mechanical capture in this amount of time. However, this may have led to selection bias and could limit the generalizability of our findings. Our sample was approximately 30% White, non-Hispanic, which does not reflect the demographic composition of the overall population of patients receiving TCP in the United States.¹ However, our multi-site design ensured that our study included patients treated by clinicians in a variety of EMS systems with diverse patient populations and multiple devices, which supports the generalizability of our findings. Importantly, the illness severity of our cohort was similar to previously published nationwide data – we calculated a mortality rate of 62.9% prior to hospital discharge compared to the 63.4% mortality rate estimated by Smida et al.¹

Because the presence of electrical capture required adjudication by human reviewers, measurement bias may have influenced our results. To minimize the influence of this potential source of bias on the interpretation of these data, we prespecified our outcome definitions, used a standardized data collection instrument, employed a

Table 2 – Post-TCP initiation cohort characteristics.

	No sustained electrical capture	Sustained electrical capture	Total
<i>N</i>	270 (90.3%)	29 (9.7%)	299 (100.0%)
TCP duration (min)	13.5 (6.0–25.7)	18.0 (7.9–29.9)	13.6 (6.1–26.4)
Final GCS <i>missing: 79</i>	3.0 (3.0–11.0) <i>missing: 69</i>	3.0 (3.0–7.0) <i>missing: 10</i>	3.0 (3.0–10.5)
Post TCP SBP <i>missing: 124</i>	113.0 (84.0–137.0) <i>missing: 116</i>	132.0 (95.0–166.0) <i>missing: 8</i>	113.0 (86.0–141.0)
Post TCP SpO ₂ <i>missing: 231</i>	96.0 (91.5–99.0) <i>missing: 210</i>	94.5 (84.5–98.5) <i>missing: 21</i>	96.0 (90.5–99.0)
Post TCP ETCO ₂ <i>missing: 133</i>	25.0 (14.0–38.0) <i>missing: 120</i>	22.5 (16.0–29.5) <i>missing: 13</i>	24.5 (14.0–38.0)
Set current (mA)	80.0 (60.0–100.0)	90.0 (80.0–100.0)	80.0 (60.0–100.0)
Peak current (mA)	87.5 (70.0–105.0)	100.0 (80.0–135.0)	90.0 (70.0–110.0)
Final pacing rate	80.0 (70.0–80.0)	80.0 (75.0–80.0)	80.0 (70.0–80.0)
Mechanical capture documented?			
No	117 (43.3%)	12 (41.4%)	129 (43.1%)
Yes	153 (56.7%)	17 (58.6%)	170 (56.9%)
Pulse palpation site			
Carotid	1 (0.7%)	1 (5.9%)	2 (1.2%)
Radial	13 (8.5%)	1 (5.9%)	14 (8.2%)
Femoral	6 (3.9%)	3 (17.6%)	9 (5.3%)
Unknown/not documented	133 (86.9%)	12 (70.6%)	145 (85.3%)
Was loss of mechanical capture documented?			
No	152 (56.3%)	15 (51.7%)	167 (55.9%)
Yes	118 (43.7%)	14 (48.3%)	132 (44.1%)
ED potassium (mmol/L) <i>missing: 116</i>	4.9 (4.2–6.1) <i>missing: 104</i>	5.2 (3.8–6.4) <i>missing: 11</i>	5.0 (4.1–6.2)

Table 2 Legend: GCS = Glasgow Coma Scale, SBP = systolic blood pressure, bpm = beats per minute, TCP = transcutaneous pacing, ETCO₂ = end tidal carbon dioxide, mA = milliamperes, mEq/L = milliequivalents per liter.

consensus review process, and reported interrater reliability for a randomly selected subset of cases. In addition, we included representative sections of ECG from all cases with sustained electrical capture in the [Supplemental Material \(Section 2.0\)](#).

Because we did not collect detailed data describing the EMS agency protocols that guided the performance of TCP, it is possible that local variations in clinical practice are responsible for our results. In addition, we did not capture data describing the underlying pathophysiology afflicting patients in this study. This may limit the interpretation of our multivariable analyses, as the disease process that caused bradycardia and hemodynamic instability may be a predictor of prognosis.

Missing data was prevalent for some of our variables of interest, including electrotherapy pad positioning, pulse palpation location, and vital signs. This prevented performance of several pre-planned analyses, including investigation of the relationship between pad position and electrical capture, the association between sustained electrical capture and blood pressure improvement, and the relationship between sustained electrical capture, post-TCP cardiac arrest, and survival. Given data suggesting that the anteroposterior electrotherapy pad position is more likely to achieve capture in comparison to anterolateral pad position during TCP,²³ pad positioning is an important area of future study.

Table 3 – Cohort outcomes, stratified by presence of sustained electrical capture.

	No sustained electrical capture	Sustained electrical capture	Total
<i>N</i>	270 (90.3%)	29 (9.7%)	299 (100.0%)
Prehospital disposition			
Transported to ED	261 (96.7%)	29 (100.0%)	290 (97.0%)
Field termination	9 (3.3%)	0 (0.0%)	9 (3.0%)
Post-TCP CPR			
No	161 (59.6%)	14 (48.3%)	175 (58.5%)
Yes	109 (40.4%)	15 (51.7%)	124 (41.5%)
Survival to discharge			
No	131 (48.5%)	18 (62.1%)	149 (49.8%)
Yes	83 (30.7%)	5 (17.2%)	88 (29.4%)
Missing	56 (20.7%)	6 (20.7%)	62 (20.7%)
CPC Score			
CPC 1	31 (11.5%)	3 (10.3%)	34 (11.4%)
CPC 2	5 (1.9%)	0 (0.0%)	5 (1.7%)
CPC 3	23 (8.5%)	1 (3.4%)	24 (8.0%)
CPC 4	1 (0.4%)	0 (0.0%)	1 (0.3%)
Dead	131 (48.5%)	18 (62.1%)	149 (49.8%)
Missing	79 (29.3%)	7 (24.1%)	86 (28.8%)

ED = emergency department, TCP = transcutaneous pacing, CPR = cardiopulmonary resuscitation, CPC = Cerebral Performance Category.

Table 4 – Factors associated with sustained electrical capture.

Covariable of interest (DAG-guided minimal adjustment set)	Adjusted odds of sustained electrical capture aOR [95% CI]
Maximum current (per 10 mA) (Monitor model, body weight) <i>n</i> = 208	1.25 [1.08, 1.45]
Body weight (Current, monitor model, sex) <i>n</i> = 208	0.95 [0.93, 0.98]
Pre-TCP heart rate (pre-TCP CPR, pre-pacing medication) <i>n</i> = 297	0.96 [0.93, 0.99]

DAG = directed acyclic graph, aOR = adjusted odds ratio, mA = milliamperes.

Conclusion

Sustained electrical capture is rare following attempted TCP in the prehospital setting, despite our observation that a majority of clinicians reported mechanical capture. Further research is needed to identify methods to increase the proportion of patients with attempted TCP who experience sustained electrical capture and determine whether this influences clinical outcomes.

Meetings

None.

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Data sharing statement

Raw data and analysis code are available on request from Tanner Smida (tts00004@mix.wvu.edu).

CRedit authorship contribution statement

Tanner Smida: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joshua M. Kimbrell:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Judah A. Kreinbrook:** Writing – review & editing, Methodology, Conceptualization. **Gabriel H. Gan:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Wesley Odom:** Writing – review & editing, Investigation. **Tom Bouthillet:** Writing – review & editing, Validation. **Brooks Walsh:** Writing – review & editing, Validation. **Michael Shukis:** Writing – review & editing, Resources. **James Scheidler:** Writing – review & editing. **P.S. Martin:** Writing – review & editing. **Ari Moskowitz:** Writing – review & editing, Methodology. **Catherine R. Counts:** Writing – review & editing, Methodology. **James Bardes:** Writing – review & editing, Supervision, Resources.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary material to this article can be found online at <https://doi.org/10.1016/j.resuscitation.2025.110934>.

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