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Clinical paper

Pre-charging the defibrillator before rhythm analysis reduces hands-off time in patients with out-of-hospital cardiac arrest with shockable rhythm

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Abstract

Aim: To evaluate the effect of pre-charging the defibrillator before rhythm analysis on hands-off time in patients suffering from out-of-hospital cardiac arrest with shockable rhythm.

Methods: Pre-charging was implemented in the Emergency Medical Service in the Central Denmark Region in June 2018. Training consisted of hands-on simulation scenarios, e-learning material, and written instructions. Data were extracted from the Danish Cardiac Arrest Registry for a 14-month period spanning the implementation of pre-charging. Patients having received at least one shock were included. Transthoracic impedance data were analysed. We recorded hands-off time and peri-shock pauses for all defibrillation procedures and the total hands-off fraction for all cardiac arrests.

Results: Impedance and outcome data were available for 178 patients. 523 defibrillation procedures were analysed. The pre-charge method was associated with shorter median hands-off time per defibrillation procedure (7.6 (IQR 5.8–9.9) vs. 12.6 (IQR 10–16.4) seconds, $p < 0.001$) but longer pre-shock pause (4 (IQR 2.7–6.1) vs 1.7 (IQR 1.2–3) seconds, $p < 0.001$) when compared to the current guideline-recommended defibrillation method. The total hands-off fraction per cardiac arrest was reduced after implementation of the pre-charge method (16.5% vs. 20.4%, $p = 0.003$). No increase in shocks to non-shockable rhythms or personnel was registered. Patients who received only pre-charge defibrillations had an increased odds ratio of return of spontaneous circulation (aOR 2.91; 95%CI 1.09–7.8, $p = 0.03$).

Conclusion: Pre-charging the defibrillator reduced hands-off time during defibrillation procedures, reduces the total hands-off fraction and may be associated with increased return of spontaneous circulation in out-of-hospital cardiac arrest with shockable rhythm.

Keywords: Defibrillation, Pre-charging, Cardiac arrest, Shockable rhythm, Cardiopulmonary resuscitation, Advanced life support

Abbreviations: TTI, transthoracic impedance, DP, defibrillation procedure, PCCA, prehospital critical care anaesthesiologist

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Introduction

In Denmark 5000 people per year suffer from out-of-hospital cardiac arrest (OHCA), with a 30-day survival rate of 16%.[1] The quality of cardiopulmonary resuscitation (CPR) is important and directly affects the rhythm conversion ratio[2] and survival.

Animal and human clinical studies have demonstrated that an increased number and prolonged duration of pauses in chest compressions adversely affect haemodynamics during CPR,[3–7] the shock conversion rate[8] and survival.[9] Consequently, recent CPR guideline revisions have focused on reducing hands-off time, and the hands-off fraction has decreased in recent years.[10]

The recommended compression-to-ventilation ratio was changed from 15:2 to 30:2 in 2005.[11,12] Resuming chest compressions after rhythm analysis and during defibrillator charging, was recommended by the American Heart Association in 2005[11] and the European Resuscitation Council (ERC) in 2010.[13] To further reduce hands-off time, a possible next step could be to charge the defibrillator before pausing chest compressions for rhythm analysis, which potentially enables rhythm analysis and defibrillation to be carried out within a single pause. Overall, human data on this subject are scarce. Otto et al. recently published a scoping review that identified only three manikin studies and a single human study on defibrillator pre-charging.[14]

The ERC Guidelines 2021 have proposed pre-charging as a reasonable alternative for well-drilled teams and mention the need for clinical studies on the subject.[15] Several Emergency Medical Services (EMS) in Denmark, Australia, New Zealand, the Netherlands and parts of the USA use pre-charging as a standard procedure, but its impacts have not been thoroughly investigated in clinical practice.[14] The aim of this study was to evaluate the effect of pre-charging on hands-off time in OHCA.

Methods

Study design

This was a retrospective observational study comparing defibrillation methods. The study period was January 1, 2018, to March 31, 2019. Pre-charging was implemented in the EMS in the Central Denmark Region in June 2018, and this month was excluded from the data analysis to assess the implementation at the organisational level before and after training. The manuscript was prepared according to the STROBE guidelines.[16]

Settings

The study was conducted in the Central Denmark Region, which has a catchment population of 1.3 million. The region operates a two-tier EMS system. The first tier consists of an ambulance with either emergency medical technicians or paramedics (hereafter paramedics) and primarily provides basic life support including manual rhythm analysis and defibrillation. The second tier is a rapid response vehicle or helicopter with a paramedic and a prehospital critical care anaesthesiologist (PCCA) providing advanced life support. Both tiers are dispatched to all cardiac arrests and use the LIFEPAK 15 monitor/defibrillator (Stryker, Redmond, WA, USA), which records transthoracic impedance (TTI) data and transmits them to a regional database.

Patients

We included adult patients (≥18 years) from the Central Denmark Region registered in the Danish Cardiac Arrest Registry who were defibrillated at least once during resuscitation. Patients with no or inadequate TTI data were excluded.

Defibrillation methods

The currently recommended defibrillation method between two cardiopulmonary resuscitation (CPR) cycles consists of pausing compressions for rhythm analysis, resuming compressions during defibrillator charging and pausing compressions during shock delivery.[15] In the current study, this is labelled the 'Standard' method (Fig. 1b). Charging the defibrillator prior to rhythm analysis pause and shocking immediately if indicated combines the analysis and peri-shock pause, which in this study is labelled the 'Precharge' method (Fig. 1a and Fig. 4 in the electronic supplement). The outdated method of pausing compressions while analysing, charging, and shocking before resuming chest compressions is labelled the 'Old' method (Fig. 1c).

Outcomes

The primary outcome was the change in hands-off time during defibrillation procedures (DP) when using the Precharge method.

Secondary outcomes at the defibrillation procedure level were the duration of pre-, post- and peri-shock pauses. We focused on comparing the Precharge method with the Standard method as the Old method is no longer recommended. The main patient-level outcome was the change in total hands-off fraction. Furthermore, we assessed the degree of implementation of Precharge in the EMS.

Implementation of Precharge

The teaching material consisted of e-learning (a nine-minute video), an e-mailed PowerPoint presentation (Microsoft, Redmond, WA, USA), and a written procedure description. All Paramedics documented that they had received information of, trained and implemented Precharge.

As of July 1, 2018, using the Precharge defibrillation method was mandatory in the EMS. Regular training in the method was required from there on. E-mail reminders were sent to paramedics and PCCA regularly. Furthermore, the EMS Dispatch Centre added the text 'remember Precharge' to the alert message sent to the dispatched units in suspected cardiac arrest cases to increase awareness.

Data sources and collection

The Danish Cardiac Arrest Registry is a national registry that stores all available data on OHCAs in Denmark.[1] The participants in the current study were identified via a regional extract from the registry consisting of basic Utstein variables. TTI data were extracted from the regional CODE-STAT™ software database (Stryker, Redmond, WA, USA). The Regional Patient Safety Database was searched to find any reported adverse events. In addition, information was collected manually from the ambulance and hospital electronic patient records.

Defibrillation data analysis

CODE-STAT™ 10.1 software was used to process the TTI data. It automatically annotates chest compressions; however, approximately 5% of the annotations are registered inaccurately.[17] Therefore, each case was verified and corrected at the level of every

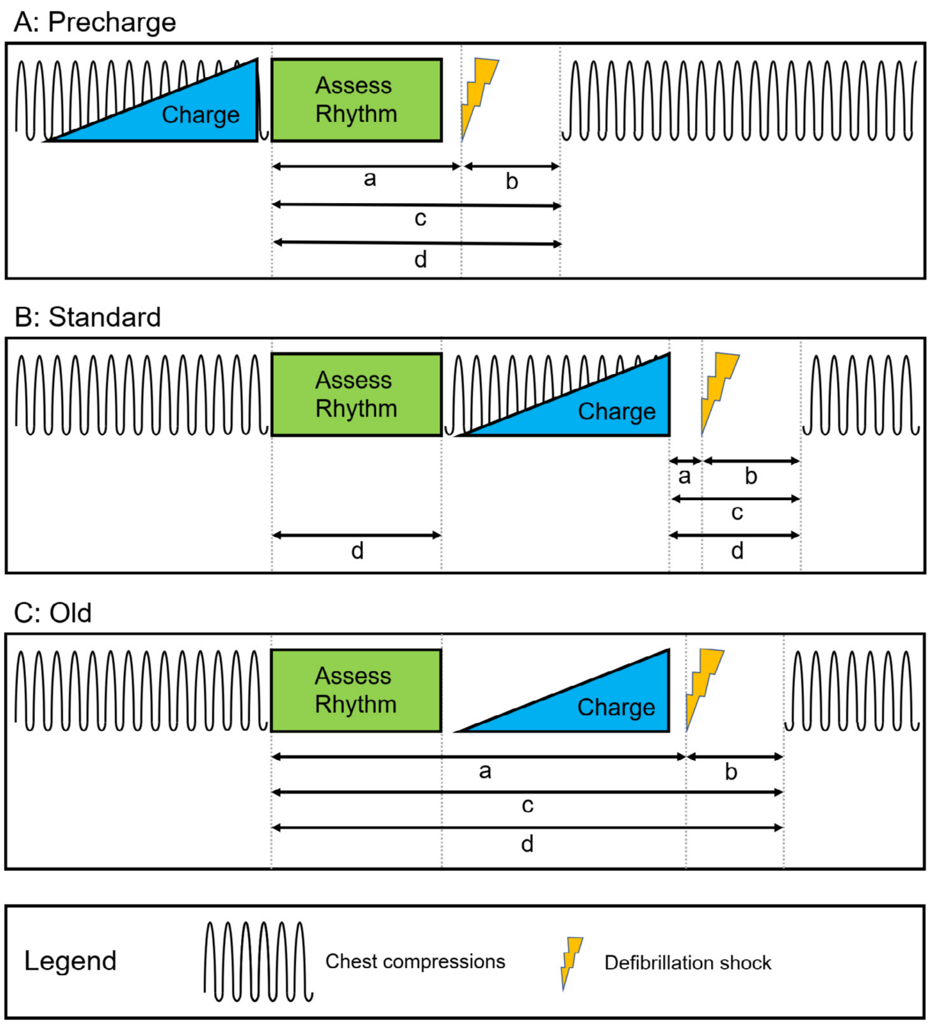

Fig. 1 – Defibrillation methods. a) Pre-shock pause (from stopping compressions until shock is delivered). b) Post-shock pause (from shock is delivered until compressions are resumed). c) Peri-shock pause (from stopping compressions until compressions are resumed). d) Hands-off time during defibrillation procedure. Figure was inspired by Otto et al.[14]

single chest compression by a PCCA (BNI) and a paramedic (CM). We defined CPR-pause intervals as the time from the trailing edge of the TTI curve of the last chest compression to the leading edge of the next chest compression. Any pause between two chest compressions longer than 1.5 seconds was recorded as recommended by Kramer-Johansen et al.[18]

The LP15 briefly freezes the TTI and electrocardiogram (ECG) signals for 2–3 seconds after the shock which contributed to a general overestimation of the post-shock pause, but this was independent of the defibrillation method.

The Standard method's analysis pause was defined as the last pause prior to the shock-pause, where the defibrillator was charged immediately after. The peri-shock pause was from the end of the last compression before shock delivery until the first definitive movement on the TTI curve, indicating resumed compressions.

The sum of the analysis pause, the peri-shock pause, and any extra compression pauses with a charged defibrillator and in immediate relation to defibrillation constituted the total hands-off time during each DP. The total hands-off fraction for the cardiac arrest was defined as the cumulative time without chest compressions in the absence of Return of Spontaneous Circulation (ROSC).

Cardiac rhythms at the time of shock delivery were analysed manually by two clinical investigators (BNI and CM) and verified by a consultant cardiologist (CJT). Shocks were considered inappropriate if delivered to non-shockable rhythms. Shock conversion was defined as the appearance of sustained QRS complexes with a rate above 40 beats/min within 60 seconds after the shock.[19]

Statistics

No formal power calculation was performed for this observational study. However, as we intended to evaluate the degree of Precharge implementation in the EMS over time, we decided on 14 months of data collection.

Results are presented as a number (percentage), mean (standard deviation (SD)) or median (interquartile range (IQR)). Categorical data were compared using the chi-square test. Continuous, normally distributed data were compared with the t-test as were non-normal continuous data after log-transformation.

The effect of Precharge on the primary outcome was analysed using multilevel mixed-effects analyses. This was adjusted for clustering of DP at the patient level and for repeated measurements and assessed overall- and between-group differences.

The effect of Precharge on patient-level outcomes was assessed after calculating the proportional use of Precharge for each patient in relation to the total number of defibrillations. This yielded a percentage (0–100%) indicative of the extent of Precharge use, which was used in linear and multivariable logistic regression models, adjusted for resuscitation duration, age, sex, bystander CPR and initial rhythm as appropriate. Adjusted odds ratios (aOR) were reported.

A two-sided p-value of <0.05 was considered statistically significant. Analyses were performed in cooperation with a biostatistician. Stata 16 (StataCorp LLC, College Station, TX, USA) was used for the analyses.

Ethical approval

This was a quality assurance project, and approval from the Regional Ethics Committee was therefore not needed according to Danish legislation. The study was approved by the hospital board of directors.

Results

During the study period, 287 OHCA patients were subjected to at least one defibrillation and 109 patients were excluded due to none or insufficient TTI data. The final patient cohort comprised 178 patients. The mean age was 68.4 years and 78.7% were male. The majority had an initial shockable rhythm and received bystander CPR (Table 1). These patients were subjected to 607 DP, of which 84 were not interpretable, resulting in 523 DP being included in the analysis (Fig. 2).

Defibrillation procedures

All three types of defibrillation methods were used both before and after implementation of Precharge. The use of Precharge increased from 13% (n = 27) of DP before implementation to 62% (n = 193) after implementation (Fig. 3).

The median hands-off time per DP was reduced by 40% when using the Precharge method versus the Standard method (7.6 (IQR 5.8–9.9) vs. 12.6 (IQR 10–16.4) seconds, p < 0.001) (Table 2). The median pre-shock pause was longer (4 (IQR 2.7–6.1) vs. 1.7 (IQR 1.2–3.9) seconds, p < 0.001) in Precharge procedures, resulting in a longer median peri-shock pause (7.3 (IQR 5.8–9.8) vs. 5 (IQR 4.1–7.3) seconds, p < 0.001). There were no differences in the duration of post-shock pauses.

In logistic regressions there was no association between rhythm conversion ratio and defibrillation method (aOR 1.27; 95 %CI 0.67–2.43, p = 0.74).

The pre-shock pause was not associated with rhythm conversion ratio (aOR 0.99; 95 %CI 0.97–1.03, p = 0.94).

Shocks were inappropriately delivered to non-shockable rhythms in 7%, 12% and 5% of Precharge, Standard and Old procedures, respectively, with no significant differences between groups (Table 2).

Patient level outcomes

Secondary outcomes concerned analyses at the patient-level.

The overall Precharge proportion (0–100%), was strongly associated with a reduced hands-off fraction (p < 0.001) when assessed by linear regression adjusted for resuscitation duration.

40 patients received only Precharge defibrillations (100% Precharge) and 91 received no Precharge defibrillations (0% Precharge) (Table 3).

Patients in the 100% Precharge group had a lower median hands-off fraction than those in the 0% Precharge group (12.2 (IQR 9.1–15.1) vs. 20.1 (IQR 16.1–24.1) %, p < 0.001). Using only Precharge defibrillations may be associated with ROSC (aOR 2.91; 95 %CI 1.09–7.8, p = 0.03).

After implementation of Precharge in the EMS, the median hands-off fraction was reduced from 20.4% to 16.5% (p = 0.003) (Table 1).

Discussion

We examined 523 DP in 178 patients with OHCA. Our main finding was that the use of Precharge reduced hands-off time in individual DP and reduced the total hands-off fraction during the resuscitation. To our knowledge, this is the first study

Table 1 – Patients' characteristics.

	Total (n = 178)	Study periods		
		Before training (n = 68)	After training (n = 110)	p-value (before vs after)
Male, n (%)	141 (78.7)	53 (78)	88 (80)	0.74^{X}
Age (years), mean (SD)	68.4 (13.5)	69.1 (13.6)	68 (13.4)	0.54^{T}
Initial shockable rhythm, n (%)	124 (69.7)	53 (78)	71 (65)	0.06^{X}
Bystander CPR, n (%)	153 (86)	55 (80.9)	98 (89.1)	0.13^{X}
Resuscitation duration (min.), median (IQR)	15.3 (6.6–30.2)	16.9 (6.7–29.1)	14.4 (6.6–31.8)	0.47^{TL}
Total hands-off fraction (%), median (IQR)	17.9 (12.7–23.1)	20.4 (15.7–23.9)	16.5 (11.3–21.7)	0.003^{TL}
Compression per min. (n), mean (SD)	111.3 (9.3)	112 (10.7)	110.8 (8.2)	0.41^{X}
Number of pauses per min. (n), mean (SD)	1.8 (0.8)	1.9 (0.7)	1.74 (0.79)	0.13^{X}
Shocks per cardiac arrest (n), median (IQR)	2 (1–4)	2 (1–4.5)	2 (1–4)	0.39^{TL}
ROSC (any), n (%)	101 (56.7)	39 (57.4)	62 (56.4)	0.9^{X}
30-day survival, n (%)	60 (33.7)	21 (30.9)	39 (35.5)	0.53^{X}

Patient data are shown for the entire study period and for the period before and after implementing pre-charging. There were no missing data for the variables in the table. CPR: cardiopulmonary resuscitation. IQR: interquartile range. Min.: minutes. ROSC: return of spontaneous circulation. SD: standard deviation. 1: Before vs. after comparison. X) X^2-test. T) Student's t-test. TL) Student's t-test on log-transformed data.

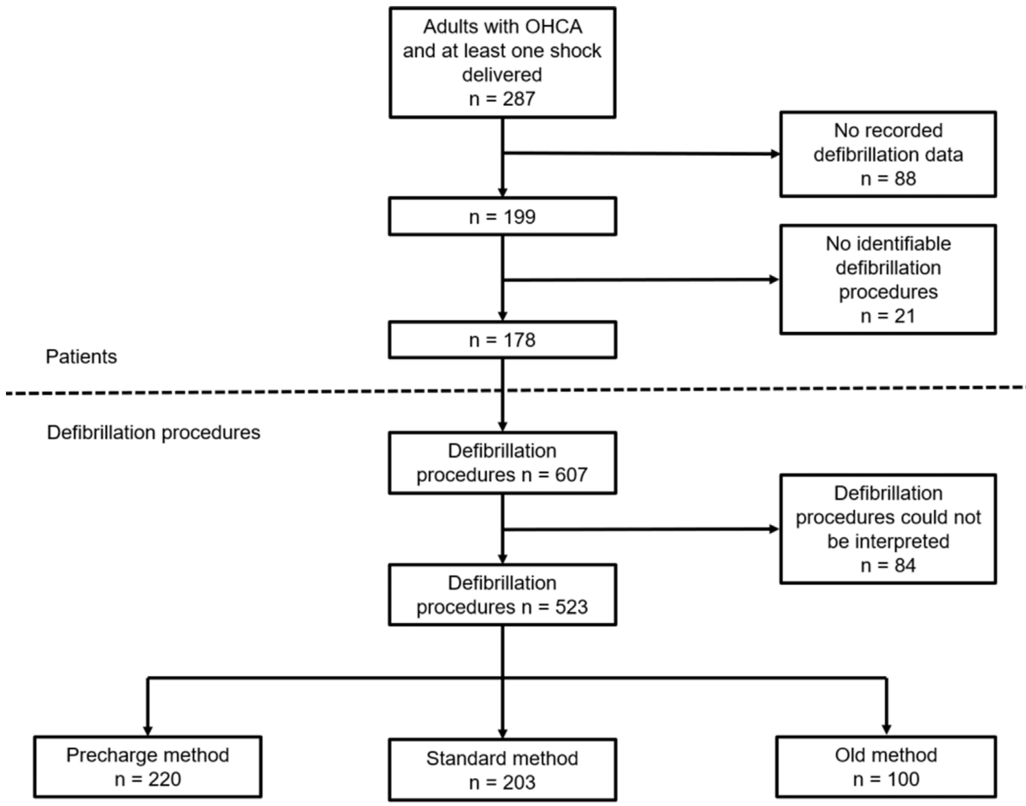

Fig. 2 – Consort diagram. OHCA: Out-of-hospital cardiac arrest.

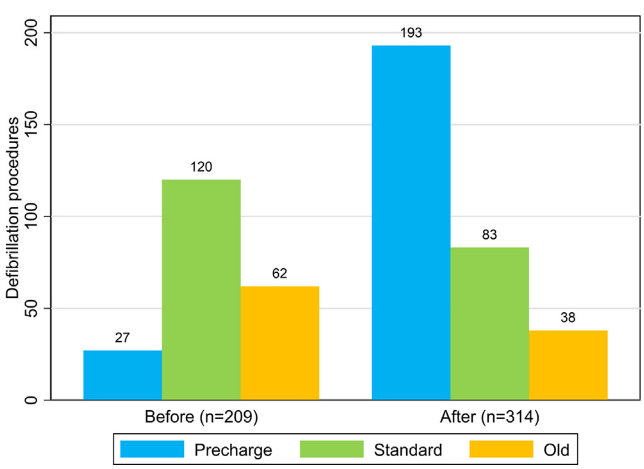

Fig. 3 – Temporal changes in the use of defibrillation methods. Distribution of defibrillation methods before and after implementing pre-charging in the Emergency Medical Service.

to demonstrate the impacts of Precharge in a prehospital setting.

When aiming to reduce hands-off time during CPR, the metrics of interest include hands-off time during the DP, the durations of the pre-, post-, and peri-shock pauses, the number of pauses during the CPR cycle and the total hands-off fraction.

A small simulation study examining the effect of pre-charging demonstrated a significant reduction in DP time and hands-off time.[20] Similarly, two simulation studies found that peri-shock pauses decreased when charging before rhythm analysis.[21,22] However, one manikin study found that the duration of peri-shock pauses increased.[23] Thus, clinical data are scarce and the impacts of pre-charging on hands-off time and durations of pre- and post-shock pauses in OHCA are uncertain.

Defibrillation procedures and peri-shock pauses

In the present study, hands-off time during DP was reduced by 40% when comparing Precharge with the Standard method. This is in line with a large retrospective in-hospital study by Edelson et al.[24] that compared the Old and Standard methods with pre-charging. Hands-off duration was recorded as the number of seconds without chest compressions in the 30 seconds preceding the shock. Pre-charging during compressions reduced hands-off time from 11.5 to 3.9 seconds.

The reduction in hands-off time during the DP when using Precharge is caused by elimination of the Standards method's analysis pause. However, as rhythm analysis is done immediately prior to defibrillation the pre-shock pause may increase. Any prolongation of pre- and peri-shock pauses, however, may be detrimental if resuming chest compressions is delayed. Edelson et al. reviewed in-hospital cardiac arrests with an initial shockable rhythm and found defibrillation success associated with shorter pre-shock pauses.[2] An OHCA study of 96 defibrillations (36 patients) found that the optimal pre-shock pause associated with defibrillation success was <3 seconds.[8] In the present study, the Standard method resulted in a median pre-shock time of 1.7 seconds, compared to 4 seconds using Precharge ($p < 0.001$). Similarly, in a simulation study, Kemper et al. found a several-second increase in pre-shock pause when pre-charging.[23]

Table 2 – Defibrillation procedures stratified according to defibrillation method (n = 523).

	Precharge (n = 220)	Standard (n = 203)	Old (n = 100)	p-value[1] (any groupdifference)	p-value[2] (Precharge vs.Standard)
Hands-off time in DP (sec.), median (IQR)	7.6 (5.8–9.9)	12.6 (10–16.4)	21.5 (16.6–25)	<0.001[M]	<0.001
Pre-shock pause (sec.), median (IQR)	4 (2.7–6.1)	1.7 (1.2–3)	16.5 (13.3–20.8)	<0.001[M]	<0.001
Post-shock pause (sec.), median (IQR)	3.1 (2.7–3.7)	3.1 (2.6–3.6)	3.4 (2.8–5)	<0.001[M]	0.94
Peri-shock pause (sec.), median (IQR)	7.3 (5.8–9.8)	5.0 (4.1–7.3)	21.5 (16.8–25.1)	<0.001[M]	<0.001
Shock to non-shockable rhythms, n (%)	16 (7.3)	25 (12.4)	5 (5)	0.17[LO]	0.16
Rhythm conversion ratio,n (%)	63 (30.9)	56 (31.5)	28 (29.5)	0.74[LO]	0.64

Multilevel mixed-effects analysis and logistic regression with the defibrillation method (Precharge, Standard, Old) as the independent variable was used. DP: defibrillation procedure. IQR: interquartile range. Sec.: seconds. SD: standard deviation. P-values are reported for 1) Any group difference and 2) Post hoc tests for between-group difference comparing Precharge vs. Standard. M) Multilevel mixed-effects analysis adjusted for repeated measurements. LO) Logistic regression adjusted for clustering of observations at the patient level.

Table 3 – Patients' characteristics stratified to adherence to the Precharge method (n = 178).

	100% Precharge (n = 40)	Mixed (n = 47)	0% Precharge (n = 91)	p-value[1] (any group difference)	p-value[2] (100% vs 0% Precharge)
Male, n (%)	31 (78)	40 (85)	70 (77)	0.51[X]	0.94
Age (years), mean (SD)	67 (12.2)	71.2 (11.2)	67.2 (14.4)	0.35[A]	0.96
Bystander CPR, n (%)	37 (93)	44 (93.6)	72 (79)	0.02[X]	0.06
Initial shockable rhythm, n (%)	26 (65)	32 (68)	66 (73)	0.7[X]	0.39
Resuscitation duration (min.), median (IQR)	12.5 (6.5–36.7)	19.4 (9.9–37.8)	15 (4.8–25.8)	0.14[A]	0.96
Total hands-off fraction (%), median (IQR)	12.2 (9.1–15.1)	15.1 (13–21.7)	20.1 (16.1–24.1)	<0.001[LI]	<0.001
ROSC (any), n (%)	26 (65)	25 (53)	50 (55)	0.04[LO]	0.03
30-day survival, n (%)	16 (40)	12 (26)	32 (35)	0.14[LO]	0.09

CPR: cardiopulmonary resuscitation. IQR: interquartile range. ROSC: return of spontaneous circulation. 1) Any group difference. 2) Post hoc test comparing the 100% vs 0% Precharge groups. Min.: minutes. A) Analysis of variance. X) X^2-test. LI) Linear regression adjusted for resuscitation duration. LO) Logistic regression adjusted for age, sex, initial rhythm, bystander cardiopulmonary resuscitation and resuscitation duration.

Importantly, the pre-shock pause in the present study when using Precharge was below the recommended 5 seconds stated in the ERC guidelines.[15]

Limiting hands-off time immediately prior to defibrillation has been shown to predict rhythm conversion success.[29] In this study, neither the defibrillation method nor the pre-shock pause affected the conversion ratio. Any detrimental effect of a slightly prolonged pre-shock pause using Precharge (4 vs. 1.7 seconds) may have been neutralised by a positive effect of elimination of the analysis pause using the Standard method resulting in a longer, uninterrupted compression period with Precharge prior to a single analysis- and shock-pause.

Cheskes et al. recorded pause durations and survival in 815 resuscitations and found that both the pre- and peri-shock pauses were inversely associated with survival, though the pauses were rather long (15.6 and 23.9 seconds).[25]

In the present study, the peri-shock pause was 7.3 seconds for Precharge procedures versus 5 seconds for Standard procedures (p < 0.001), which was due to the aforementioned difference in the pre-shock pause. A peri-shock pause increase of two seconds when pre-charging was also noted by Edelson et al.[24]

The benefit of the compressions while charging in the Standard method is debatable as the generated circulation in this brief period might be suboptimal, and several chest compressions are needed to achieve optimal aortic and coronary arterial pressures.[26] Using Precharge and thereby removing the analysis pause reduces hands-off time and increases the duration of uninterrupted compression periods between defibrillations.

Patient level outcomes

In addition to the peri-procedural hands-off time, we recorded the total hands-off fraction for each patient, where 20% or below is considered good-quality CPR.[27] It was reduced from 20.4% to 16.5% (p = 0.003) after implementing Precharge in the EMS, which seems to have been driven by a marked increase in the use of Precharge (Fig. 3). In support of this, proportional Precharge use was strongly associated with reduced hands-off fraction (p < 0.001), and a comparison of groups of patients with 100% versus 0% Precharge proportion use showed a point reduction of 7.9% (p < 0.001) in hands-off fraction in the 100% Precharge group. However, other factors may have contributed to this, such as increased general effort towards decreasing hands-off time as a result of implementing a novel defibrillation method in the EMS or general improvements in CPR quality over time. The total hands-off fraction is known to predict ROSC[28] and survival[9]. In an exploratory analysis using 100% Precharge defibrillations was associated with ROSC (p = 0.03) and 30-day survival (p = 0.09). We believe a Precharge-mediated decreased hands-off fraction may have contributed to these associations. The study was not designed to detect differences in these secondary patient-level outcomes, but further investigation seems warranted (Table 3).

No accidental shocks were delivered to the included patients. No incidents related to the Precharge method were reported to the Regional Patient Safety Database during the study. In simulation and human studies, pre-charging was found to be safe for providers and easy to learn.[22,24,30]

The number of shocks to non-shockable rhythms did not increase when pre-charging, which is in line with previous findings.[24] Surprisingly, we found that use of the Standard procedure had a non-significant but numerically higher rate of shocks to non-shockable rhythms. Hypothetically, this could be due to unnoticed rhythm conversion while charging and a lack of reassessment before shock delivery.

In summary, the advantages of Precharge seems to be a reduction of hands-off time during DP, a reduction of total hands-off fraction, the elimination of one compression pause per DP and an increase in uninterrupted CPR time between two DP. These advantages may lead to improved patient-related outcomes and should be weighed against the disadvantage of a slightly prolonged pre-shock pause which had no detectable negative effect in this study.

Limitations

This study had some limitations. First, it was observational, and the patients were not randomised to specific defibrillation methods. Approximately one third of patients were excluded due to either an absence of TTI data or uninterpretable TTI data, but we have no reason to believe that this was related to the charging method, and the survival rate was similar in both groups.

Second, this study included selected cardiac arrests where shock was delivered at least once; thus, the results cannot be extrapolated to cardiac arrests with non-shockable rhythms.

Third, adherence to the local cardiac arrest guidelines with regard to the defibrillation method was limited both before and after implementing Precharge. For individual paramedics and PCCA, OHCA are infrequent occurrences, which makes implementing new standards challenging.

Finally, teams of PCCA and paramedics that used Precharge may have performed better in other areas of the resuscitation effort such as strict adherence to guidelines, timely drug delivery and other unmeasured differences.

Conclusion

The Precharge method reduces hands-off time during defibrillation procedures, reduces the total hands-off fraction and may consequently be associated with increased ROSC rate in OHCA patients with shockable rhythms. The rate of shocks to non-shockable rhythms or accidental shocks were not increased. We propose increased emphasis on pre-charging in future cardiac arrest guidelines. Controlled studies examining patient-level outcomes are warranted.

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Conflicts of interest

All authors declare no conflicts of interest.

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2021.09.037.

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