Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Clinical paper

Distribution and use of automated external defibrillators and their effect on return of spontaneous circulation in Danish hospitals

Mathilde Stærk[a,b], Kasper G. Lauridsen[c,d,e], Kristian Krogh[c,f], Bo Løfgren[a,c,g,*]

[a] Department of Medicine, Randers Regional Hospital, Denmark
[b] Education and Research, Randers Regional Hospital, Denmark
[c] Research Center for Emergency Medicine, Aarhus University Hospital, Denmark
[d] Emergency Department, Randers Regional Hospital, Denmark
[e] Department of Anesthesiology and Critical Care Medicine, Children's Hospital of Philadelphia, USA
[f] Department of Anaesthesiology and Intensive Care, Aarhus University Hospital, Denmark
[g] Department of Clinical Medicine, Aarhus University, Denmark

Abstract

Introduction: Automated external defibrillators (AEDs) increase survival after out-of-hospital cardiac arrest. However, the effect of AEDs for in-hospital cardiac arrest (IHCA) remains uncertain. This study aims to describe the distribution and use of AEDs in Danish hospitals and investigate whether early rhythm analysis is associated with return of spontaneous circulation (ROSC).

Methods: All Danish public hospitals with a cardiac arrest team were included and sent a questionnaire on the in-hospital distribution of AEDs and manual defibrillators. Further, we collected data on IHCAs including rhythm analysis, device type, cardiac arrest team arrival, and ROSC from the national database on IHCA (*DANARREST*).

Results: Of 46 hospitals, 93% had AEDs and 93% had manual defibrillators. AEDs were often placed in wards or non-clinical areas, whereas manual defibrillators were often placed in areas with high-risk patients. We identified 3,204 IHCAs. AEDs were used in 13% of IHCAs. After adjustment for confounders, chance of ROSC was higher if the first rhythm analysis was performed before the arrival of the cardiac arrest team (RR: 1.28 (95% CI: 1.12–1.46)). The relative risk of ROSC was 1.09 (0.84–1.41) when analyzing with an AED before cardiac arrest team arrival and 1.19 (1.00–1.41) when using a manual defibrillator. However, there was no significant effect modification for AED vs manual defibrillator ($p = 0.26$).

Conclusion: AEDs are widely distributed in Danish hospitals but less commonly used for IHCAs compared to manual defibrillators. Rhythm analysis before arrival of the cardiac arrest team was associated with ROSC without significant effect modification of device type.

Keywords: Automated external defibrillator, In-hospital cardiac arrest, Return of spontaneous circulation, Defibrillation

Introduction

The chance of survival after in-hospital cardiac arrest (IHCA) is low and reported to be 20–30%.[1–5] Early defibrillation within minutes after cardiac arrest increases the chance of survival and is recommended as a key element in the Chain of Survival.[6–8] Automated external defibrillators (AEDs) make earlier defibrillation possible and improve survival after out-of-hospital cardiac arrest.[9–11] AEDs are therefore widely distributed in the prehospital setting.[12,13] During IHCA, several minutes may pass before arrival of the cardiac arrest team and a manual defibrillator.[5,6,14] Thus, deployment of AEDs is recommended in areas of a hospital with a risk of delayed defibrillation despite sparse evidence of benefit for AED use in hospitals.[7]

Studies on the benefit of AEDs for IHCA are limited and conflicting. Some studies report an increase in survival when using AEDs for IHCA.[15,16] In contrast, others report no benefit or a decreased risk of

* Corresponding author at: Department of Medicine, Randers Regional Hospital, Skovlyvej 15, 8930 Randers NE, Denmark.
E-mail address: bl@clin.au.dk (B. Løfgren).

https://doi.org/10.1016/j.resplu.2022.100211
Received 2 December 2021; Received in revised form 19 January 2022; Accepted 19 January 2022
Available online xxxx

survival when using AEDs.[17,18] The reason for these findings is unknown but may be related to, e.g. the distribution of AEDs within the hospitals and the situations where AEDs are used.

Accordingly, this study aims to describe the distribution and use of AEDs in Danish hospitals and investigate whether rhythm analysis before the cardiac arrest team arrival is associated with return of spontaneous circulation.

Methods

Study design

We used data from a nationwide cross-sectional questionnaire on the in-hospital distribution of AEDs and the Danish national database of in-hospital cardiac arrests, *DANARREST*. The study was approved by the Danish Data Protection Agency (j.no. 2012-58-006, case no. 1-16-02-202-18). According to Danish law, no Ethical Committee approval was required.

Questionnaire

We included all public hospitals in Denmark with a cardiac arrest team. A cardiac arrest team was defined as a team consisting of at least two hospital staff members allocated to respond to cardiac arrest. To be included in the study, hospitals must have such a team present at least part of the day. Hospitals treating outpatients only were excluded. A list of all public hospitals in Denmark was obtained from the Danish Regions which is the administrating body for Danish public hospitals. Each hospital was contacted and inquired about the inclusion criteria and contact information of the hospital's medico-technical department.

A questionnaire (Appendix A) was sent by email to a medical technician responsible for each hospital's defibrillators. The questionnaire included information on 1) if AEDs were available in the hospital, 2) the number of AEDs, 3) the model of AEDs, 4) the location of AEDs, 5) how often the AEDs were used, 6) if the hospital had manual defibrillators, 7) the model of the manual defibrillators, 8) the location of manual defibrillators, and 9) how often the manual defibrillators were used. The questionnaire was developed by the researchers behind this study and created using SurveyMonkey (SurveyMonkey Inc., San Mateo, CA, USA). Another resuscitation researcher reviewed the questionnaire before distribution to ensure face validity.

Hospitals not responding were sent reminders by email at week 2, 4, and 8, and by telephone at week 6 and 10 after the initial distribution of the questionnaire.

DANARREST

DANARREST is the Danish national database on IHCAs.[19] All IHCAs with a clinical indication for cardiopulmonary resuscitation (CPR) are included in the database. The database contains descriptive data as well as quality indicators related to the process of care and clinical outcome. We included data on initial rhythm, type of defibrillator (i.e., AED or manual), time to first rhythm analysis, time to first defibrillation, time to arrival of the cardiac arrest team, and return of spontaneous circulation (ROSC) from 2016 and 2017.

Data from *DANARREST* were reviewed to ensure the data quality; Obvious typing errors were corrected, whereas erroneous time registration (e.g., negative time registration, time of resuscitation termination days after arrest etc.) were excluded. Conflicting data (e.g., no defibrillation/yes defibrillation, first shock by AED/first shock by manual defibrillator) were excluded.

Statistics

Data were analyzed for normality using histograms and QQ plots. Categorical data are presented as percentages (n), and continuous data are reported as median (1st quartile; 3rd quartile). Data were analyzed using R-statistics (version 3.4.0, R Core Team 2017, R Foundation for Statistical Computing, Vienna, Austria) and Stata Statistical Software (version 16, StataCorp. 2019, College Station, TX, USA).

Associations between rhythm analysis before the cardiac arrest team arrival and ROSC was calculated using modified Poisson regression (Poisson distribution and log-link function). We accounted for clustering within hospitals using generalized estimating equations and adjusted for cardiac arrest team response time, witnessed cardiac arrest, and hospital department. Covariates for adjustment was chosen based on directed acyclic graphs (i.e., causal diagrams). We assessed for effect modification of device type (AED or manual defibrillator) and initial rhythm (shockable or non-shockable) by introducing interaction terms in the models. We did not include cases with missing data on rhythm analysis and/or ROSC. As missing data for other covariates were very limited, we did not use imputation analysis. Data are reported as relative risks (RR) with 95% confidence intervals (95% CI).

Results

Questionnaire

In total, 46 hospitals were eligible for inclusion, and all hospitals replied (response rate: 100%) between February 7th and April 20th, 2017. Both AEDs and manual defibrillators were available at 87% (n = 40) of hospitals, 7% (n = 3) of hospitals only had AEDs, and 7% (n = 3) of hospitals only had manual defibrillators. Each hospital had a median of 10 (5; 24) AEDs and 11 (7; 20) manual defibrillators. The location of AEDs and manual defibrillators are shown in Table 1. During the previous year, hospitals reported that AEDs were used 2 (0; 10) times per hospital, equal to each AED being used 0.7 times. Manual defibrillators were reported to be used 15 (2; 50) times per year, equal to each manual defibrillator used 2.7 times within the previous year. Overall, 33% (n = 14) of hospitals had compatible AEDs and manual defibrillators, i.e., AED electrodes could be directly connected to the manual defibrillator, 55% (n = 24) of hospitals would require an adaptor to connect electrodes, 10% (n = 4) of hospitals did not have compatible AEDs and manual defibrillators, i.e., the electrodes were to be changed when switching from the AED to a manual defibrillator, while this was unknown at 2% (n = 1) of hospitals.

DANARREST database

In 2016 and 2017, 4,496 data entries were registered in *DANARREST*. Of these, 1,292 data entries were excluded due to not being a cardiac arrest (n = 883) or having no indication to resuscitate (n = 409). In total, data were analyzed for 3,204 IHCAs. Time variables were excluded for 70 data entries and corrected for 86 data entries. Variables regarding defibrillation/no defibrillation (n = 31) and defibrillation device used for first rhythm analysis/defibrillation (AED/manual defibrillator) (n = 9) were excluded due to conflicting data.

Overall, 79% (n = 2,519) of arrests were witnessed (data missing for 3 IHCAs), 17% (n = 538) had shockable rhythm (data missing for 27 IHCAs), 49% (n = 1,582) had non-shockable rhythm, and 33%

Table 1 – Location of AED/manual defibrillators and IHCAs in Danish hospitals.

	AED		Manual defibrillator	
	Device locations[a] (n = 43 hospitals)	Device use[b,c] (n = 414 IHCAs)	Device locations[a] (n = 43 hospitals)	Device use[b,c] (n = 797 IHCAs)
Wards[d]	63% (27)	83% (343)	63% (27)	51% (407)
Emergency department	42% (18)	6% (23)	79% (34)	17% (139)
Out-patient clinics	12% (5)	2% (10)	14% (6)	<1% (3)
Surgery	19% (8)	1% (3)	58% (25)	2% (13)
Department of Anesthesiology and ICU	19% (8)	3% (11)	74% (32)	16% (129)
Other location[e]	84% (36)	6% (23)	23% (10)	13% (106)
Missing	-	1	-	-

[a] Data from the questionnaire.
[b] Data from DANARREST.
[c] ECG-monitoring used for rhythm analysis in 505 IHCAs, unknown device used in 427 IHCAs, no initial rhythm analysis registered in 1034 IHCAs, and data regarding device missing for 27 IHCAs.
[d] Device placed at one or more wards within a hospital.
[e] For example radiology, cafeteria, waiting areas, hallways, remote buildings, non-patient areas e.g., administration, outdoors.

(n = 1,057) had no rhythm analysis. Median cardiac arrest team response time was 3 (2; 4) min, median time to rhythm check was 2 (1; 4) min, and 54% (n = 1,726) achieved ROSC (data missing for 24 IHCAs). An AED was used for at least rhythm analysis in 13% (n = 414) of resuscitation attempts. The locations of the IHCAs are shown in Table 1. Of these, 15% (n = 63) had initial shockable rhythm, and 83% (n = 345) had initial non-shockable rhythm (data missing for 6 IHCA). ROSC was achieved in 59% (n = 37) of patients with shockable rhythms and 46% (n = 158) with non-shockable rhythms. For IHCAs with a shockable rhythm and usage of an AED, rhythm analysis was performed before the arrival of the cardiac arrest team in 52% (n = 32) of cases, and subsequent defibrillation with an AED was performed in 78% (n = 25) of these cases (Table 2). After adjustment for known confounders (clustering within hospitals, cardiac arrest team response time, witnessed cardiac arrest, and hospital department), first rhythm analysis before the arrival of the cardiac arrest team was associated with a higher chance of ROSC when compared to rhythm analysis after the arrival of the cardiac arrest team, RR: 1.28 (95% CI: 1.12–1.46) (Table 3). We found no significant effect modification of AED vs manual defibrillator (p = 0.26) or shockable vs non-shockable rhythms (p = 0.79). Analysis of smaller subgroups of patients having rhythm analysis with AED only and shockable rhythms only were also non-significant (Table 3).

Table 2 – Time registration.

	All IHCA with AED use 13% (n = 414)		
	Before CAT arrival	At CAT arrival	After CAT arrival
Rhythm analysis with AED (n = 398)[a]	42% (166)	32% (126)	27% (106)
	Shockable IHCA with AED use 15% (n = 63)		
	Before CAT arrival	At CAT arrival	After CAT arrival
Rhythm analysis with AED (n = 61)[b]	52% (32)	25% (15)	23% (14)
Subsequent defibrillation with AED (n = 49)[c]	51% (25)	20% (10)	29% (14)
Subsequent defibrillation with manual defibrillator (n = 4)	50% (2)	25% (1)	25% (1)
No defibrillation (n = 5)	60% (3)	20% (1)	20% (1)
Unknown device (n = 0)	0	0	0
ROSC (if defibrillated) (n = 30)[d]	67% (20)	20% (6)	13% (4)
Time to first shock (median)	2 (2; 3) min	2 (1; 2.5) min	5 (4; 8) min

Data presented as percentages (n) or median (Q1, Q3). CAT = cardiac arrest team, ROSC = return of spontaneous circulation.
[a] Data missing for 16 IHCA.
[b] Data missing for 2 IHCA.
[c] Data missing for 3 IHCA.
[d] Data missing for 3 IHCA.

Table 3 – Adjusted relative risk of ROSC if rhythm analysis before cardiac arrest team arrival compared to rhythm analysis after arrival of the cardiac arrest team.

	Adjusted RR (95% CI)
Use of AED	
All rhythms	1.09 (0.84–1.41)
Shockable rhythms	1.59 (0.87–2.92)
Non-shockable rhythms	0.96 (0.68–1.35)
Use of manual defibrillator	
All rhythms	1.19 (1.00–1.41)
Shockable rhythms	0.90 (0.61–1.32)
Non-shockable rhythms	1.18 (1.00–1.41)
Use of any device	
All rhythms	1.28 (1.12–1.46)
Shockable rhythms	1.15 (0.86–1.53)
Non-shockable rhythms	1.22 (1.05–1.40)

RR = relative risk, CI = confidence interval, AED = automated external defibrillator, ROSC = return of spontaneous circulation.

Discussion

We found that AEDs and manual defibrillators are widely distributed in Danish hospitals. AEDs are less commonly used for IHCA than manual defibrillators, and rhythm analysis before the arrival of the cardiac arrest team is associated with a higher chance of ROSC.

Despite the limited evidence, AEDs are widely distributed in Danish hospitals but only used in one of ten resuscitation attempts. We found AEDs to be located in wards and non-clinical areas of the hospital (e.g., cafeteria, hallways etc.) where the first responders may be hospital staff or laypersons only trained in basic life support. The cardiac arrest team response time may be long in such areas. In contrast, manual defibrillators were often placed in locations with more high-risk patients, e.g., emergency departments and intensive care units where the hospital staff is more likely to be trained in advanced life support, including the use of manual defibrillators. Placement of AEDs in these areas may not be either cost-effective or affect the outcome after IHCA.

The finding that rhythm analysis before cardiac arrest team arrival was associated with a higher chance of ROSC for non-shockable rhythms could potentially be due to higher CPR quality by providers performing early rhythm analysis (i.e., early rhythm analysis indicating better overall CPR skills). However, we adjusted for hospital department and hospital site to account for location-specific confounding in terms of CPR quality and AED use, although we were unable to account for CPR quality specifically. Moreover, we found a difference between AEDs and manual defibrillators, suggesting a higher chance of ROSC for non-shockable rhythms when using a manual defibrillator but not when using an AED. This may be due to the staff administering early adrenaline when finding a non-shockable rhythm on the manual defibrillator, which is associated with improved survival outcomes.[20–22] In contrast, responders using an AED are most likely only trained in basic life support, thus without competency to administer adrenaline. Unfortunately, the *DANARREST* database does not include time to first adrenaline dosing, limiting our knowledge on this issue.

We found no significant effect modification of AEDs vs manual defibrillators suggesting a beneficial effect of early rhythm analysis irrespective of device type. Thus, our finding supports that hospitals should ensure access to swift rhythm analysis/defibrillation in all areas of the hospital. Notably, our subgroup analysis on the use of AEDs did not show a significant benefit on ROSC. This finding is in accordance with previous studies.[17,18] However, our finding may owe to type 2 error due to the limited sample size. Furthermore, it is unknown if high-quality CPR before cardiac arrest team arrival will attenuate the beneficial effect of AEDs for shockable rhythms.

It may be difficult to demonstrate a survival benefit of AEDs for IHCAs in contrast to out-of-hospital cardiac arrests.[9–11,23] Many factors may influence the in-hospital use of AEDs. A study found no increase in the chance of ROSC if an AED were used compared to cases with no AED use.[24] However, if the AED was used adequately (defined as application within 3 minutes, shock delivered if shockable rhythm and with no delay, and no shock delivered if non-shockable rhythm), there was a higher chance of achieving ROSC. Another study found an AED-user dependent time loss when the user awaits the entire “chain of advice” instead of placing the defibrillation electrodes immediately, suggesting that lacking user-skills attenuates the benefit of AEDs.[25] Further, a study indicated that suboptimal use of AEDs are common, which may be due to long retraining intervals combined with low exposure to IHCA among ward nurses.[14] Finally, the interruption in chest compressions during rhythm analysis and shock delivery is generally prolonged when using an AED compared to a manual defibrillator which decreases survival.[26].

Future studies should seek to identify in which in-hospital locations AEDs could have a beneficial effect on survival as it seems unlikely that AEDs will improve hospital-wide survival. Importantly, factors such as training of staff members, rates of shockable rhythms, and the arrival of the cardiac arrest team may affect the location-specific effect of having AEDs in the hospital. In addition to location, studies exploring hospital staff's use of AEDs to optimize the use seems likewise warranted.

Limitations

Our study was based on data from a questionnaire and a database. Even though the questionnaire was answered by a person responsible for maintaining the hospital's AEDs (and/or manual defibrillators), the answers provided may differ from the actual use of the devices. Further, manual defibrillators may also be used in AED-mode. However, we assume hospitals based their answers regarding device type on the common use of the device i.e., in AED- or manual mode.

Database data are prone to inaccuracies in time stamps.[27–29] The data reported to the *DANARREST*-database are reported after the occurrence of an IHCA by a member of the cardiac arrest team. There may therefore be some recall bias as well as missing knowledge to actions performed. Further, some IHCAs may not have been reported as the cardiac arrest registration was recently initiated in several hospitals in 2016–2017. In addition, *DANARREST* does not contain data on patient demographics and which specific ward (e.g., surgical, cardiology, other internal medical) the IHCA occurred. Thus, we cannot infer the relative use of AEDs and manual defibrillators, respectively. Finally, our sample size is limited and not powered for subgroup analyses.

Conclusion

AEDs are widely distributed in Danish hospitals but less commonly used for IHCAs compared to manual defibrillators. Rhythm analysis before arrival of the cardiac arrest team was associated with ROSC without significant effect modification of device type.

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.

CRediT authorship contribution statement

Mathilde Stærk: Conceptualization, Methodology, Resources, Investigation, Writing – original draft, Writing – review & editing, Project administration. **Kasper G. Lauridsen:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Kristian Krogh:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Bo Løfgren:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision.

Acknowledgements

We thank all participating hospitals. We thank Randers Regional Hospital, Aarhus University, Laerdal Foundation, The A.P. Møller Foundation for the Advancement of Medical Science (*Fonden til Lægevidenskabens Fremme*), the Health Foundation (*Helsefonden*), and Health Research Foundation of Central Denmark Region for financial support.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2022.100211.

REFERENCES

1. Nolan JP, Soar J, Smith GB, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. Resuscitation 2014;85:987–92.
2. Kolte D, Khera S, Aronow WS, et al. Regional variation in the incidence and outcomes of in-hospital cardiac arrest in the United States. Circulation 2015;131:1415–25.
3. Ehlenbach WJ, Barnato AE, Curtis JR, et al. Epidemiologic study of in-hospital cardiopulmonary resuscitation in the elderly. New Engl J Med 2009;361:22–31.
4. Sandroni C, Nolan J, Cavallaro F, Antonelli M. In-hospital cardiac arrest: incidence, prognosis and possible measures to improve survival. Intensive Care Med 2007;33:237–45.
5. DANARREST. DANARREST - Registrering af hjertestop på hospital. Årsrapport 2018; 2018 May 2019.
6. Sandroni C, Ferro G, Santangelo S, et al. In-hospital cardiac arrest: survival depends mainly on the effectiveness of the emergency response. Resuscitation 2004;62:291–7.
7. Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.
8. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2015;132:S414–35.
9. Berdowski J, Blom MT, Bardai A, Tan HL, Tijssen JG, Koster RW. Impact of onsite or dispatched automated external defibrillator use on survival after out-of-hospital cardiac arrest. Circulation 2011;124:2225–32.
10. Blom MT, Beesems SG, Homma PC, et al. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014;130:1868–75.
11. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. New Engl J Med 2000;343:1206–9.
12. Brooks SC, Hsu JH, Tang SK, Jeyakumar R, Chan TCY. Determining risk for out-of-hospital cardiac arrest by location type in a canadian urban setting to guide future public access defibrillator placement. Ann Emerg Med 2013;61. 530-8.e2.
13. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Hiraide A. Nationwide public-access defibrillation in Japan. N Engl J Med 2010;362:994–1004.
14. De Regge M, Monsieurs KG, Vandewoude K, Calle PA. Should we use automated external defibrillators in hospital wards? Acta Clin Belg 2012;67:241–5.
15. Zafari AM, Zarter SK, Heggen V, et al. A program encouraging early defibrillation results in improved in-hospital resuscitation efficacy. J Am Coll Cardiol 2004;44:846–52.
16. Destro A, Marzaloni M, Sermasi S, Rossi F. Automatic external defibrillators in the hospital as well? Resuscitation 1996;31:39–43. discussion -4.
17. Chan PS, Krumholz HM, Spertus JA, et al. Automated external defibrillators and survival after in-hospital cardiac arrest. JAMA 2010;304:2129–36.
18. Forcina MS, Farhat AY, O'Neil WW, Haines DE. Cardiac arrest survival after implementation of automated external defibrillator technology in the in-hospital setting. Crit Care Med 2009;37:1229–36.
19. Andersen LW, Østergaard JN, Antonsen S, et al. The Danish in-hospital cardiac arrest registry (DANARREST). Clin Epidemiol 2019;11:397–402.
20. Finn J, Jacobs I, Williams TA, Gates S, Perkins GD. Adrenaline and vasopressin for cardiac arrest. Cochrane Database Syst Rev 2019;1. Cd003179.
21. Perkins GD, Ji C, Deakin CD, et al. A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest. New Engl J Med 2018;379:711–21.
22. Holmberg MJ, Issa MS, Moskowitz A, et al. Vasopressors during adult cardiac arrest: A systematic review and meta-analysis. Resuscitation 2019;139:106–21.
23. Holmberg MJ, Vognsen M, Andersen MS, Donnino MW, Andersen LW. Bystander automated external defibrillator use and clinical outcomes after out-of-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation 2017;120:77–87.
24. Wutzler A, Kloppe C, Bilgard AK, Mugge A, Hanefeld C. Use of automated external defibrillators for in-hospital cardiac arrest: Any time, any place? Medizinische Klinik, Intensivmedizin und Notfallmedizin 2019;114:154–8.
25. Wurmb T, Vollmer T, Sefrin P, et al. Monitoring of in-hospital cardiac arrest events with the focus on Automated External Defibrillators–a retrospective observational study. Scandin J Trauma Resuscit Emerg Med 2015;23:87.
26. Cheskes S, Schmicker RH, Christenson J, et al. Perishock pause: an independent predictor of survival from out-of-hospital shockable cardiac arrest. Circulation 2011;124:58–66.

27. Kaye W, Mancini ME, Truitt TL. When minutes count–the fallacy of accurate time documentation during in-hospital resuscitation. Resuscitation 2005;65:285–90.
28. Stewart JA. Problems with time-interval data from In-hospital resuscitation records. Int J Cardiol 2016;223:879–80.
29. Grundgeiger T, Albert M, Reinhardt D, Happel O, Steinisch A, Wurmb T. Real-time tablet-based resuscitation documentation by the team leader: evaluating documentation quality and clinical performance. Scandin J Trauma Resuscit Emerg Med 2016;24:51.