

Decreasing time to first shock: Routine application of defibrillation pads in prehospital STEMI

Sarah Felder, MD*[‡]; Kristine VanArsen, MSc[†]; Matthew Davis, MD, MSc^{†‡}

CLINICIAN'S CAPSULE

What is known about the topic?

Shorter time to initial defibrillation in patients with ventricular fibrillation/tachycardia arrests increases favourable neurologic survival.

What did the study ask?

Does routine application of defibrillation pads in prehospital ST-elevation myocardial infarction (STEMI) patients decrease time to initial defibrillation in out-of-hospital cardiac arrest?

What did the study find?

Mean time to initial defibrillation was 17.7 seconds in the "pads-on protocol," compared with 72.7 seconds in routine care.

Why does this study matter to clinicians?

Routinely applying defibrillation pads to STEMI patients decreases time to initial defibrillation, which has been found to increase survival in out-of-hospital cardiac arrest.

2016). Records were reviewed for relevant patient and event features. T-test was used to measure the difference between mean times to defibrillation.

Results: 446 patients were diagnosed with prehospital STEMI. 11 suffered OHCA while in paramedic care. The mean (SD) age was 66.0 (9.3) and 55% were female. In the 4 patients treated with the "pads-on" protocol, the mean time to initial defibrillation was 17.7 seconds, compared to 72.7 seconds in patients who had pads applied following arrest (Δ 55.0 sec [95% CI 22.7–87.2 s]).

Conclusion: Routine application of defibrillation pads in STEMI patients who suffer OHCA decreases time to initial defibrillation, which has previously been demonstrated to increase favourable neurologic survival.

RÉSUMÉ

Introduction: Quatre pour cent des infarctus du myocarde avec élévation du segment ST (STEMI) se compliquent d'un arrêt cardiaque en milieu extrahospitalier. D'après la recherche, plus le temps écoulé avant la première décharge électrique chez les patients présentant de la fibrillation ou de la tachycardie ventriculaires (FV/TV) est court, meilleures sont les chances de survie neurologiques. L'étude visait donc à déterminer si l'application systématique des électrodes de défibrillation, en phase préhospitalière, chez les patients ayant subi un STEMI diminuait le temps écoulé avant la première décharge dans les cas d'ACEH.

Méthode: Il s'agit d'un examen de dossiers médicaux d'adultes ayant subi un STEMI en milieu préhospitalier, de janvier 2012 à juillet 2016. Étaient sélectionnés les patients qui, d'après l'ECG à 12 dérivations, était révélateur d'un STEMI, suivi d'un ACEH par FV/TV, pendant la prestation des soins paramédicaux. L'étude a été conçue de manière à permettre l'évaluation du protocole d'« application systématique des électrodes », avant (janv. 2012 à mai 2014) et après (juin 2014 à juillet 2016) sa mise en œuvre. L'examen des dossiers portait sur la collecte de faits et de cas pertinents. L'écart (Δ) du temps moyen écoulé avant la défibrillation, entre les deux phases, a été mesuré à l'aide de la méthode du test T.

ABSTRACT

Introduction: Four percent of ST-elevation myocardial infarctions (STEMIs) are complicated by an out-of-hospital cardiac arrest (OHCA). Research has shown that shorter time to initial defibrillation in patients with ventricular fibrillation/tachycardia (VF/VT) arrests increases favourable neurologic survival. The purpose of this study is to determine whether routine application of defibrillation pads in patients with prehospital STEMI decreases the time to initial defibrillation in those who suffer OHCA.

Methods: This was a health records review for adult patients diagnosed with STEMI in the prehospital setting from January 2012 to July 2016. Patients were included if they had a 12 lead ECG indicative of STEMI and subsequently suffered VF/VT OHCA while in paramedic care. This study was designed to evaluate the effects of the "pads-on" protocol in a pre (Jan 2012-May 2014) /post implementation fashion (Jun 2014- Jul

From *St. Thomas Elgin General Hospital, Emergency Medicine Department, St. Thomas, ON; †Division of Emergency Medicine, Department of Medicine, University of Western Ontario, London, ON; and the ‡Southwest Ontario Regional Base Hospital Program, London Health Sciences Centre, London ON.

Correspondence to: Dr. Matthew Davis, 4056 Meadowbrook Dr. Unit 145 London, ON N6L 1E5; Email: matthew.davis@lhsc.on.ca

Résultats: Un diagnostic de STEMI a été posé chez 446 patients en phase préhospitalière. Sur ce nombre, 11 ont subi un ACEH pendant la prestation des soins paramédicaux. L'âge moyen (écart type) était de 66,0 ans (9,3), et 55% des patients touchés étaient des femmes. Le temps moyen écoulé avec la première décharge chez les 4 patients traités selon le protocole d'« application systématique des électrodes » était 17,7 secondes contre 72,7 secondes chez les patients chez qui l'application des

électrodes suivait l'arrêt cardiaque (Δ : 55,0 secondes [IC à 95% : 22,7–87,2 s]).

Conclusion: L'application systématique des électrodes de défibrillation chez les patients ayant subi un STEMI suivi d'un ACEH diminue le temps écoulé avant la première décharge, intervention qui, d'après la recherche, accroît les chances d'une survie neurologique favorable.

Keywords: Cardiac arrest, prehospital/EMS

INTRODUCTION

Annually, there are approximately 400,000 out-of-hospital cardiac arrests (OHCA) in North America, with an average survival rate of 10%–12%.¹ Ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) is the initial rhythm in approximately 20% of these patients. Studies have demonstrated that the probability of survival in VF/VT OHCA decreases as time to initial defibrillation increases. Patients with witnessed VF/VT OHCA have greater rates of functional neurologic survival when times from onset to initial defibrillation are shorter.^{2–5}

Observational studies suggest that up to 4% of all ST-elevation myocardial infarctions (STEMI) are complicated by OHCA.^{6,7} Commonly, paramedics responded to such events by applying defibrillation pads at the time of arrest and defibrillating as quickly as possible. A case report of a “pads-on” protocol describes a case in which defibrillation pads were applied to a patient with STEMI with the aim of decreasing time to potential initial defibrillation.⁸ Two cases of STEMI complicated by VF were reported. The time to initial defibrillation was 2 minutes 43 seconds for the patient who required application of pads following arrest, but the time to initial first defibrillation was only 27 seconds in the “pads-on” protocol patient.

The purpose of this study was to evaluate the difference in time to initial defibrillation in patients with STEMI who experience OHCA after implementation of a “pads-on” protocol and describe the effects of this protocol on outcomes including survival to hospital discharge.

METHODS

Study design and time period

This was a health records review of patients with STEMI diagnosed in the prehospital setting pre- (Jan 2012 to

May 2014) and post- (Jun 2014 to Jul 2016) implementation of a new protocol. In June 2014, paramedics began routinely applying defibrillation pads to patients with presumed STEMI. All patients with STEMI treated by Middlesex-London Paramedic Service Primary Care and Advanced Care Paramedics between January 2012 and July 2016 were included. This study was approved by the research ethics board of Western University.

Population

Patients were identified by searching all ambulance call reports during the study period with any of the following data codes: “STEMI,” “CPR,” or “defibrillation.” Cases of patients ≥ 18 years of age were reviewed if diagnosed with prehospital STEMI, and the diagnosis was confirmed on review of prehospital ECGs. STEMI was defined as at least 2 mm of ST elevation in leads V1–V3 in or at least 1 mm of ST elevation in any other leads, with the presence of ST elevation in at least two anatomically contiguous leads. Patients were included if they subsequently experienced a VF/VT arrest while in paramedic care. Patients were excluded if they arrested prior to a prehospital STEMI diagnosis or if they had a valid “do not resuscitate” order.

Data abstraction and analysis

Ambulance call reports of included patients were reviewed for patient demographics, event features (e.g., number of defibrillations, length of transport, doses of epinephrine, and airway interventions), and time to initial defibrillation. Other secondary outcomes were obtained from hospital records including intensive care unit (ICU) admission, admission duration, survival to hospital discharge, and discharge disposition. Time to defibrillation was tested for normality, and a *t*-test was

used to assess the difference in time to initial defibrillation between the two groups.

RESULTS

Between January 2012 and July 2016, 446 patients were diagnosed with prehospital STEMI. Eleven of these patients experienced a paramedic-witnessed VF/VT arrest. The mean (standard deviation [SD]) age was 66.0 (9.3) years, and 55% were female. Seven patients underwent application of defibrillation pads following arrest with a mean (SD) time to initial defibrillation of 72.7 (34.9) seconds. In the four patients treated with the “pads-on” protocol, the mean (SD) time to initial defibrillation was 17.7 (4.2) seconds. The mean difference between the two groups was 55.0 seconds (95% confidence interval [CI] 22.7–87.2).

Characteristics of the 11 patients with prehospital STEMI who experienced OHCA are detailed in Table 1. Most patients (9 out of 11) presented and maintained normal vital signs prior to their cardiac arrest (defined as systolic blood pressure >100, heart rate [HR] ≥60 and <100, and oxygen saturation ≥95% on room air). Nine of 11 (81.8%) patients experienced return of spontaneous circulation (ROSC) with one defibrillation attempt. After one defibrillation attempt, six of the seven in the pre-intervention group achieved ROSC, and three of the four patients in the “pads-on” group had ROSC (Appendix 1). No patient required invasive airway management by paramedics. All four of the “pads-on” group survived to hospital discharge, and six

of the seven in the “pre-intervention” group survived to hospital discharge. Seven of the 11 (63.6%) patients were found to have a culprit left anterior descending artery lesion at the time of angiography. Ten of the 11 patients survived to angiography. Of these 10 patients, all 10 survived to hospital discharge to an independent setting within 14 days of admission.

DISCUSSION

In this study, routine applications of defibrillation pads in patients with prehospital STEMI who experienced OHCA was associated with a decreased time to initial defibrillation. These findings are in keeping with the case report published by Osei-Ampofo et al.⁸ Although causation cannot be assumed in our study, time to defibrillation is a relatively objective measure that should not be unduly influenced by a patient or other event variables. All patients in the “pads-on” protocol group survived to hospital discharge, but one patient in the pre-intervention group did not survive. Although this study was not designed to show a survival benefit, previous studies indicate that each minute delay in the time to initial defibrillation is associated with a 7%–10% decrease in patient survival to hospital discharge.^{2–5} In our study, the intervention was able to decrease time to initial defibrillation by 55 seconds.

Of note, there was wide variability in time to first defibrillation in the pre-intervention group and less variability in the “pads-on” group. Factors that may account

Table 1. Characteristics of patients with STEMI who experienced VF/VT arrest while in EMS care

Patient ID	“Pads-on” protocol	Initial vital signs	Time to first defibrillation (sec)	ROSC with paramedics	Transport length (min)	Angiogram lesion	Admission to ICU	Duration of hospital stay (days)
1	No	Normal	119	Yes	25	LAD	No	3
2	No	Hypotensive	91	Yes	37	Unknown	No	Deceased
3	No	Normal	55	Yes	25	LAD	No	7
4	No	Normal	109	Yes	28	LAD	Yes	11
5	No	Normal	66	No	29	RCA	Yes	10
6	No	Normal	45	Yes	38	LAD	No	5
7	No	Normal	24	Yes	30	RCA	No	2
8	Yes	Hypotensive	15	No	26	LAD	No	3
9	Yes	Normal	16	Yes	38	LAD	No	7
10	Yes	Normal	16	Yes	26	RCA	Yes	13
11	Yes	Normal	24	Yes	29	LAD	No	3

ICU = intensive care unit; LAD = left anterior descending artery; RCA = right coronary artery; ROSC = return of spontaneous circulation

for this difference in the pre-intervention group can include time required to find pads in bags, connect to monitor, apply to patient, and safely defibrillate during a time of critical stress.

Only 2 of the 11 patients with post-STEMI OHCA had concerning vital signs prior to their arrest, thus indicating that all patients with prehospital STEMI, including those with normal vital signs, may benefit from early application of defibrillation pads. Lethal arrhythmias can occur suddenly in well-looking patients with prehospital STEMI and normal vital signs, thus making it difficult for paramedics to predict which patients will deteriorate into a VF or pulseless VT rhythm.

This study was limited by its small size and not powered to control for variables such as transport time, type of paramedic crew, patient age, and comorbidities that may affect time to initial defibrillation and impact outcomes such as survival. The results are at risk of error because of the reliance of documented event times. However, no patients were excluded because of inadequate or missing data. Furthermore, paramedic delay to recognition of VF/VT could not be controlled for as a confounding factor that might have contributed to longer defibrillation times in the pre-intervention group. Only 2.5% of patients with prehospital STEMI experienced OHCA while in paramedic care during the study period. This is lower than anticipated based on previously documented rates of OHCA in patients with STEMI patients.^{6,7} This discrepancy may be attributed to the fact that this study did not capture patients who experienced a cardiac arrest prior to the diagnosis of STEMI. Given that few patients with prehospital STEMI potentially derive benefit, cost-benefit analysis requires consideration. Because of the adherence of removal of expired pads from stock and their general infrequent use, the implementation of this protocol resulted in no additional costs to the paramedic service involved in this study.

CONCLUSION

This study suggests that routinely applying defibrillation pads to patients diagnosed with STEMI in the

prehospital setting significantly decreases time to initial defibrillation that has been previously found to be a predictor of increased survival in OHCA. These results would benefit from validation in a prospective setting.

Supplementary material: The supplementary material for this article can be found at <https://doi.org/10.1017/cem.2019.408>.

Acknowledgements: The authors would like to thank Middlesex-London Paramedic Service, Superintendent of Education Mr. Jay Loosley and frontline Middlesex-London paramedics for their involvement with this study and their continued commitment and contributions to high quality care and collaboration in resuscitation research.

Competing interests: None.

REFERENCES

1. Benjamin EJ, Muntner P, Alonso A, et al. Heart disease and stroke statistics – 2019 update: A report from the American Heart Association. 2019;139(10):e56–e528.
2. Drennan IR, Lin S, Thorpe KE, Morrison LJ. The effect of time to defibrillation and targeted temperature management on functional survival after out-of-hospital cardiac arrest. *Resuscitation* 2014;85(11):1623–8.
3. 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(21):1868–75.
4. Chan PS, Krumholz HM, Nichol G, Nallamothu BK; American Heart Association National Registry of Cardiopulmonary Resuscitation Investigators. Delayed time to defibrillation after in-hospital cardiac arrest. *N Engl J Med* 2008;358(1):9–17.
5. Berdowski J, ten Haaf M, Tijssen JG, Chapman FW, Koster RW. Time in recurrent ventricular fibrillation and survival after out-of-hospital cardiac arrest. *Circulation* 2010;122(11):1101–8.
6. Lettieri C, Savonitto S, De Servi S, et al. Emergency percutaneous coronary intervention in patients with ST-elevation myocardial infarction complicated by out-of-hospital cardiac arrest: early and medium-term outcome. *Am Heart J* 2009;157(3):569–75.e1.
7. Mylotte D, Morice MC, Eltchaninoff H, et al. Primary percutaneous coronary intervention in patients with acute myocardial infarction, resuscitated cardiac arrest, and cardiogenic shock: the role of primary multivessel revascularization. *JACC Cardiovasc Interv* 2013;6(2):115–25.
8. Osei-Ampofo M, Cheskes S, Byers A, et al. A novel approach to improve time to first shock in prehospital STEMI complicated by ventricular fibrillation. *Prehosp Emerg Care* 2016;20(2):278–82.