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Review

Defibrillation in rural areas

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ABSTRACT

Aim of the study: Automated external defibrillation (AED) and public access defibrillation (PAD) have become cornerstones in the chain of survival in modern cardiopulmonary resuscitation. Most studies of AED and PAD have been performed in urban areas, and evidence is scarce for sparsely populated rural areas. The aim of this review was to review the literature and discuss treatment strategies for out-of-hospital cardiac arrest in rural areas.

Methods: A Medline search was performed with the keywords *automated external defibrillation* (617 hits), *public access defibrillation* (256), and *automated external defibrillator public* (542). Of these 1415 abstracts and additional articles found by manually searching references, 92 articles were included in this nonsystematic review.

Results: Early defibrillation is crucial for survival with good neurological outcome after cardiac arrest. Rapid defibrillation can be a challenge in sparsely populated and remote areas, where the incidence of cardiac arrest is low and rescuer response times can be long. The few studies performed in rural areas showed that the introduction of AED programs based on a 2-tier emergency medical system, consisting of Basic Life Support and Advanced Life Support teams, resulted in a decrease in collapse-to-defibrillation times and better survival of patients with out-of-hospital cardiac arrest.

Conclusions: In rural areas, introducing AED programs and a 2-tier emergency medical system may increase survival of out-of-hospital cardiac arrest patients. More studies on AED and PAD in rural areas are required.

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1. Introduction

In North America, the incidence of out-of-hospital cardiac arrest (OHCA) is approximately 50 to 55 per 100 000 inhabitants per year [1,2]. Sudden cardiac arrest is caused by myocardial infarction in more than 60% of cases, with ventricular fibrillation (VF) in 50% to 80% of collapsed patients [3,4]. In urban areas with rapid bystander cardiopulmonary resuscitation (CPR) and public access defibrillation (PAD), survival rates from cardiac arrest have improved substantially [5]. Most studies on automated external defibrillation (AED) and PAD have been performed in urban areas (eg, Maastricht, Netherlands, with a population density of 1975 inhabitants km^{-2}; Goteborg, Sweden, with 2562 inhabitants km^{-2}; and Copenhagen, Denmark, with 5985 inhabitants km^{-2}) [6–8]. Data are scarce in less densely populated rural and mountain areas such as the European Alps, with a population density of about 20 to 240 inhabitants km^{-2}, or Oregon, USA, with 15 inhabitants km^{-2}. It is unclear how to equip rural areas with AEDs and PAD. The aim of this review was to review the literature and discuss evidence regarding treatment strategies for OHCA-VF in rural areas.

2. Material and methods

A literature search of the Medline database was performed using the keywords *automated external defibrillation* (617 hits), *public access defibrillation* (256), and *automated external defibrillator public* (542) for articles published on or before July 18, 2014. A manual search of the references was performed to find additional articles. In total, 92 articles related to AED and PAD in rural areas were included in this nonsystematic review.

3. Results and discussion

3.1. Collapse-to-defibrillation time is decisive for survival and neurological outcome

Time from OHCA-VF to defibrillation is crucial for survival and neurological outcome. The defibrillation success and survival rate of OHCA-VF patients not receiving CPR rapidly decline in the first 5 to 10

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Table 1
Influence of emergency medical technician defibrillation programs within EMS on survival from OHCA

Studies (n = 1713)	Design	Survival to hospital discharge before and after implementation of AED		P
		Before	After	
Eisenberg et al, 1980 [38] (n = 154)	Prospective, historical controls	4%	19%	<.01
Stults et al, 1984 [39] (n = 95)	Prospective controlled	3%	19%	<.05
Olson et al, 1989 [40] (n = 566)	Prospective controlled	4%	6%	<.02
Sweeney et al, 1998 [41]*(n = 627)	Prospective controlled, crossover	5%	5%	.8
Gottschalk et al, 2002 [42]*(n = 103)	Prospective controlled	32%	22%	.29
Stotz et al, 2003 [43]*(n = 168)	Retrospective	24%	14%	.112

Studies on early defibrillation within the emergency medicine system. ED denotes early defibrillation.
* Studies in areas where the response time of the ALS team before introduction of the AED program was a few minutes.

minutes after collapse [9]. Other studies also report a steep decline in survival [10,11], which underlines that a response time shorter than 5 minutes has the biggest impact on positive outcome [11–17]. In a British study, patients with OHCA-VF witnessed by a physician had a survival rate of about 60% when the outpatient clinics where they collapsed were equipped with AEDs [18]. The response time was also decisive for survival: the hospital discharge rate was about 60% with a response time of less than 4 minutes and about 18% with a response time of more than 4 minutes. Automated external defibrillation studies with long call-to-defibrillation intervals (eg, >10 minutes) have not demonstrated a substantial increase in the overall survival rate [19].

Short response times after OHCA-VF are also essential for good neurological outcome. In Amsterdam, survivors of OHCA-VF had less neurological impairment and loss of autonomy when the collapse-to-CPR and collapse-to-defibrillation times were shorter [20,21]. Another study reported that life expectancy and quality of life were similar in patients who had survived OHCA-VF compared to a matched population [22].

Whereas early studies suggested a benefit of CPR before defibrillation [23–27], recent studies do not support these findings [28–33]. Thus, current CPR guidelines do not recommend a specific CPR interval before defibrillation but highlight the importance of efficient and continuous chest compressions with as short as possible hands-off time until successful defibrillation [25,34,35].

3.2. Early defibrillation programs in urban areas within emergency medical services

Emergency medical services (EMSs) have different structures. A single-tier EMS consists of an Advanced Life Support (ALS) team that is called to an emergency; a 2-tier system consists of Basic Life Support (BLS) and ALS teams that are dispatched according to medical information and needs. Other systems have a nontransporting first responder team whose members are BLS or ALS trained and a transporting unit that is dispatched simultaneously. Two-tier systems may be more cost-effective because less qualified personnel and less equipment are needed to provide a good standard of care [36]. In a review, survival from OHCA-VF ranged from 3% to 33% but was higher with a 2-tier compared to a single-tier system [37]. The greatest improvements in survival from OHCA-VF were reported in areas where no preclinical defibrillation was available before these programs were introduced [38–40]. However, the advantage of a 2-tier system could not be replicated in areas where the response time of an ALS team had been fast (within minutes) before the program was introduced [41–43]. As a result, both the American Heart Association and European Resuscitation Council recommend that BLS teams should be equipped with AEDs [44]. Studies reporting outcomes after early defibrillation in urban areas within an EMS are listed in Table 1.

3.3. Early defibrillation programs in urban areas outside EMS

In some 2-tier systems, BLS AED is performed by BLS first responders trained in the use of AEDs, for instance, fire brigade members and police officers. These first responders perform continuous CPR and apply AED until the arrival of an ALS team. A 2-tier system outside the EMS can shorten call-to-defibrillation time; and it may improve outcome if the call-to defibrillation time is reduced to a few minutes, especially in areas where an ALS team is not rapidly available [3,15,45–50]. Some studies did not report improved outcomes because call-to defibrillation time could not be sufficiently reduced (eg, <10 minutes). Studies reporting outcomes after early defibrillation in urban areas outside an EMS are listed in Table 2.

3.4. Public access defibrillation

Public access defibrillation is defined as the installation of AEDs in public places (eg, airplanes, airports, casinos). Introduction of PAD in densely populated or heavily frequented areas can increase preexisting

Table 2
Influence of AED programs outside the EMS on survival from OHCA

Studies (n = 7942)	Design	Responders	Controls	Survival to hospital discharge before and after implementation of AED		P
				Before	After	
van Alem et al, 2003 [3] (n = 469)	Prospective controlled, randomized, crossover	Police, firefighters	EMS	15%	18%	.33
Stiell et al, 1999 [15] (n = 6331)	Prospective controlled, interventional	Firefighters, EMT-D	EMS	4%	5%	.03
Myerburg et al, 2002 [45] (n = 420)	Prospective controlled	Police	EMS	9%	17%	.05
Kellermann et al, 1993 [46] (n = 431)	Prospective controlled, crossover	Firefighters	EMS	10%	14%	NS
White et al, 1996 [47] (n = 84)	Retrospective	Police, EMT-D	EMS	43%	58%	.2
Mosesso et al, 1998 [48] (n = 207)	Prospective interventional, historical controls	Police	EMS	6%	14%	.1

EMT-D denotes emergency medical technician with AED skills; NS, nonsignificant.

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