The contribution of lay rescuers in out-of-hospital cardiac arrest
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CHAPTER 1

Introduction and outline
1.1 EPIDEMIOLOGY

Out-of-hospital cardiac arrest is a leading cause of death in industrialized countries, affecting 275,000 individuals per year in Europe.\(^1\) In the United States, approximately 350,000 patients with an out-of-hospital cardiac arrest are treated annually.\(^2\) The majority of out-of-hospital cardiac arrests have a cardiac cause and in 50% of the patients it is the first sign of a cardiovascular disease.\(^3\)\(^5\) Despite much effort, out-of-hospital cardiac arrest is generally reported as having poor outcome, with survival rates varying between 5% and 20%.\(^6\)

1.2 EARLY DEFIBRILLATION

The importance of early defibrillation

The most important predictor of out-of-hospital cardiac arrest survival is the presence of a shockable initial rhythm: ventricular fibrillation (VF) or rapid ventricular tachycardia (VT). The only treatment for these rhythms is the application of a defibrillation shock. However, when time elapses VF will gradually dissolve into asystole and consequently the chance of survival decreases.\(^7\) This process may be delayed but not prevented by cardiopulmonary resuscitation (CPR). Each minute that defibrillation is delayed reduces the chance of survival by approximately 8–10%.\(^4\)

The last two decades, reported proportions of shockable rhythms in out-of-hospital cardiac arrest have declined worldwide; dropping from proportions as high as 70% to proportions as low as 24%\(^8\)\(^9\). Nowadays, the percentages of shockable rhythms ranges from 47% in the Netherlands\(^10\) to 28% in Denmark,\(^11\) 24% in the United States\(^12\) and 18% in Sweden.\(^13\) One of the explanations for the relatively high percentage of shockable initial rhythms in the Netherlands might be the high rate of CPR given to the patient prior to arrival of the ambulance (75%).\(^10\)

Strategies to increase early defibrillation

Early defibrillation is essential for survival. An automated external defibrillator (AED) allows (lay) rescuers to initiate treatment prior to ambulance arrival at the cardiac arrest site. To increase early defibrillation, AED programs have been introduced including first responder programs.\(^14\)\(^15\) The dispatcher may send first responders, like police officers or fire fighters, with an AED to the scene of the cardiac arrest. Additionally, public access defibrillation programs also have contributed to earlier defibrillation of out-of-hospital cardiac arrest patients.\(^16\)\(^20\) In such programs, AEDs are placed at specific locations where people gather such as shopping malls, hotels, sports facilities, airports, or public and office buildings. Training lay persons and first responders, as well as placing AEDs in public places, has resulted in improved survival.\(^21\)\(^26\)
Epidemiological paradox
The chance to survive a cardiac arrest in a residential area is lower than in public.\textsuperscript{27} The most important explanations for this lower survival are fewer witnessed arrest, less bystander CPR and (consequently) a lower prevalence of shockable initial rhythms. The benefit of AED initiatives aimed at patients collapsing in a residential area is therefore expected to be less than those aimed at patients collapsing in public areas. Nevertheless, approximately 75\% of out-of-hospital cardiac arrests occur in a residential area. Despite the lower prevalence of shockable initial rhythms in these areas, patients who collapse from a shockable rhythm in a residential area outnumber those patients who collapse in public. Unfortunately, AEDs placed in public areas are almost never used for residential out-of-hospital cardiac arrest patients.\textsuperscript{17,28} Previous research in the Netherlands showed that only 9\% of the onsite AEDs were connected to a cardiac arrest patient who collapsed in a residential area.\textsuperscript{29}

1.3 SITUATION IN THE NETHERLANDS

Emergency response to an out-of-hospital cardiac arrest
When a cardiac arrest is suspected, the dispatcher sends two ambulances equipped with a manual defibrillator and first responders (e.g. police officers and firefighters) with an AED. Besides first responders, onsite (lay) rescuers can also apply an AED. First responders are dispatched as part of the organized response to a cardiac arrest: their training only includes the standard European Resuscitation Council basic life support training for lay rescuers that includes instructions for AED use. Dutch first responders only perform tasks according to this training.

Time to the first shock
In the province of North-Holland, the time between the call to the Dutch national emergency number and the first shock provided by an ambulance defibrillator has shown to be approximately 11 minutes, resulting in a survival rate of only 14\% (Figure 1.1).\textsuperscript{29}

First responders are dispatched to both public and residential areas. In general, their response times are faster than ambulance response times. Previous research has shown that it takes first responders approximately 8,5 minutes to provide the first shock with an AED (about 2,5 minutes shorter than defibrillation by ambulance personnel), resulting in a survival rate of 17\%.\textsuperscript{29}

Onsite AEDs, that are primarily located and used in public areas, have been the first connected type of defibrillator in approximately 5\% of the out-of-hospital cardiac arrests. Patients treated with an onsite AED have a survival rate of almost 50\%. This is attributable to the rapid provision of a defibrillation shock (4.1
minutes). However, as indicated above, only a small proportion of out-of-hospital cardiac arrests occur in public places where an onsite AED may be present.

**Bridging the gap**

Approximately three-quarters of the out-of-hospital cardiac arrests occur in a residential area, where onsite AEDs are often not available. Cardiac arrest patients collapsing in a residential area are in need of a type of responder that can bridge the ‘time gap’ between first responders, who can reach all locations but are not fast enough, and an onsite AED, that is usually very close to the cardiac arrest location but can be used to help only a small proportion of patients.

To achieve early defibrillation, also in residential areas of the Netherlands, a text message alert system has been designed and implemented. This system uses text messages to alert local lay rescuers trained in basic life support, so-called text message responders, in the vicinity of the cardiac arrest patient. The dispatcher manually activates the system, simultaneously or shortly after sending the first ambulance.

![Figure 1.1 Time between the emergency call and the first shock provided by the three types of responders in the Netherlands: onsite responder, first responder and ambulance personnel.](image-url)
1.4 PSYCHOLOGICAL IMPACT

Impact of attempting a resuscitation

Resuscitation attempts are stressful events and may lead to severe stress including post-traumatic stress disorder (PTSD), even in ambulance personnel. In two studies, Axelsson et al. studied the psychological reactions and experiences of bystanders. They demonstrated that bystanders regarded their intervention as a mainly positive experience and that it is important to have someone to talk to soon after a resuscitation. Davies et al. investigated the psychological profile of first responders to gain insight into possible factors that might protect them in stressful situations, such as a resuscitation. A realistic appreciation of their own limitations, confidence in their ability to perform as trained and being able to handle positive and negative outcomes showed to be prominent features.

There are, however, no studies that report on the impact on lay rescuers after performing a resuscitation. In contrast to professional rescuers, lay rescuers may only rarely be involved in resuscitation. However, their contribution to the resuscitation becomes more extensive since they do not only perform CPR but also may connect an AED and defibrillate. It is therefore important to study if lay rescuers are able to cope with the impact and stress that originates from resuscitating a patient.

Posttraumatic stress disorder

According to the American Psychiatric Association the essential feature of posttraumatic stress disorder is the development of characteristic symptoms following exposure to an extreme traumatic stressor involving direct personal experience of an event or witnessing an event that involved actual or threatened death or serious injury, or other threat physical integrity of self or others. Symptoms that often arise include persistent re-experiencing the traumatic event (e.g. nightmares), persistent avoidance of stimuli associated with the trauma and numbing of general responsiveness and persistent symptoms of increased arousal (e.g. concentration problems, quickly irritated). These symptoms are common after a traumatic event and usually will gradually decline within the first four to six weeks after the event. The international guidelines for PTSD advice to screen for persons at risk for the development of PTSD. Four to six weeks after the event, a brief screening instrument for PTSD can be used, e.g. the Impact of Event Scale.
1.5 AED PERFORMANCE

The overall performance of an AED is dependent on the device’s ability to identify shockable and non-shockable heart rhythms and on the operator’s ability to use the device correctly. In 1997 the American Heart Association Task Force on Automatic External Defibrillation, published recommendations for specifying and reporting AED algorithm performance. These recommendations describe diagnostic criteria and performance standards for both shockable and non-shockable heart rhythms. Manufacturers use test benches of ECG recordings to test if their AED meets the performance standards. However, reports about AED performance in cases of real life out-of-hospital cardiac arrest are scarce.

With increasing use of AEDs, incidental reports of AED failure emerge in the Netherlands. In January 2013, the Dutch Healthcare Inspectorate received several incident reports from manufacturers of AEDs that relate to not delivering the required shock, sometimes with fatal outcome for the patient. In most of these cases it was, however, unclear whether there was a specific relation to an operator error or a device failure. The Dutch Healthcare Inspectorate concluded that there is uncertainty about the procedure for using an AED, whether the prescriptions in the Dutch instructions for use have been followed, and about the extent and manner of the preventive maintenance of such AEDs, prescribed by the manufacturer.

Since AEDs are increasingly used by first responders and lay rescuers, who may use an AED only rarely and may therefore have difficulties operating the AED, it is important to evaluate AED performance when used by these kind of rescuers.

1.6 ARREST STUDY AREA

AmsteRdam REsuscitation STudies (ARREST) is an ongoing prospective registry of all out-of-hospital cardiac arrests in the Dutch province of North-Holland (without Gooi-en Vechtstreek), which since 2010 also includes the region Twente (Figure 1.2). The studies in this thesis involve only a part of the total ARREST study area: North-Holland North and Twente. These two regions have a comparable number of inhabitants: 645,421 and 626,726, respectively. Both regions have a mix of small to mid-size cities and small villages, and an inhabited surface area of 1420 and 1489 km², respectively.

1.7 OUTLINE OF THIS THESIS

Chapter 2 provides an extensive description of the functioning of the text message alert system with the focus on response times and early defibrillation in relation
to other dispatched and onsite responders. Chapter 3 describes whether the text message alert system contributes to improved survival in out-of-hospital cardiac arrest patients with a shockable initial rhythm. In chapter 4, we describe the short-term perceived psychological impact of lay rescuers performing bystander CPR and the level of PTSD-related symptoms four to six weeks after the resuscitation. Additionally, we show which factors contribute to a higher level of PTSD-related symptoms in these lay rescuers. Finally, in chapter 5 we present to what extent AEDs that are operated by lay rescuers and first responders are ‘failing’ and whether this is caused by device-related or operator-related errors. This thesis is concluded with a chapter summarizing these results and some future directions.
REFERENCES


