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How can we optimize bystander basic life support in cardiac arrest?

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Göteborg 2007

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Printed at Intellecta Docusys
ISBN 978-91-628-7341-7

It is one of the most beautiful compensations of life, that no man can try to help another without helping himself

Ralph Waldo Emerson

ABSTRACT

The aim of this thesis was to describe various aspects of cardiopulmonary resuscitation (CPR) and CPR training in order to find approaches for enhancing bystander interventions. Cardiac care patients (n=401) were interviewed with regard to their attitude toward CPR and CPR training (II). Among those who were co-habiting (n=268), possibilities for and obstacles in relation to training were investigated (III). An instrument for measuring quality of CPR performance was tested in a pilot study using a suitable selection of cardiac care nurses (I, n=10). Quality of performance was studied among laypersons after CPR training and three months later (IV, n=32). A qualitative method was used to describe spouses' experiences during the cardiac arrest (CA) at home. Fifteen spouses were interviewed (V).

Most of the cardiac care patients had a positive attitude towards CPR and many had trained or wished to undergo training in CPR (II). Two-thirds of patients who were co-habiting were unsure or doubted that their co-habitant had CPR training. More than half of these wanted their co-habitant to attend a course. Younger patients were more willing to participate in CPR training than those who were older. Major obstacles for CPR training were their own medical condition, and doubts concerning co-habitants physical ability or interest in participation (III). Measurements of the quality of CPR performance revealed several points of concern regarding CPR training and skill-retention; the difficulties in making the pauses for ventilations short enough, leading to low number of chest compressions per minute and poor performance regarding ventilations (I, IV). Immediately after training the laypersons performed relatively high proportions of chest compressions correctly, which after three months decreased significantly. 'Too shallow' chest compressions were common whilst the cardiac care nurses often made chest compressions 'too deep'. Spouses' experience of CA included two time domains and seven themes. Prior to the CA the themes deal with spouses' perceptions and interpretations of early warning signs. When a CA developed spouses quickly perceived the seriousness of the situation. Some lacked the ability to intervene whilst others did everything in their power to influence the outcome. The Emergency call services played an important supportive role and guided spouses in performing CPR (V).

Conclusion: CPR training for cardiac care patients and co-habitants is important and feasible. The outcome of training has to be enhanced. Simplification of the message and reduction in number of skills taught seems urgent. Symptoms and signs regarding myocardial infarction have to be communicated more clearly.

Key words: Out-of-hospital cardiac arrest; CPR; Education; Training; Spouses; Experience; Qualitative content analysis

LIST OR ORIGINAL PAPERS

This thesis is based on the following papers which are referred to by Roman numerals:

I

Ann-Britt Thorén, Åsa Axelsson, Stig Holmberg, Johan Herlitz
Measurement of skills in cardiopulmonary resuscitation - do professionals follow given guidelines?
European Journal of Emergency Medicine. 2001; 8:169-176.

II

Ann-Britt Thorén, Åsa Axelsson, Johan Herlitz
The attitude of cardiac care patients towards CPR and CPR education
Resuscitation. 2004;61:163–171.

III

Ann-Britt Thorén, Åsa Axelsson, Johan Herlitz
Possibilities for, and obstacles to, CPR training among cardiac care patients and their co-habitants
Resuscitation. 2005;65:337–343.

IV

Ann-Britt Thorén, Åsa Axelsson, Johan Herlitz
Inferior skill retention among lay persons three months after training in cardiopulmonary resuscitation
In manuscript

V

Ann-Britt Thorén, Ella Danielson, Johan Herlitz, Åsa Axelsson
Spouses' experiences of a cardiac arrest at home: an interview study
Submitted for publication

ABBREVIATIONS

AHA	American Heart Association
CABG	Coronary Artery Bypass Grafting (Surgery)
CAD	Coronary Artery Disease
CPR	Cardiopulmonary Resuscitation
ECC	Emergency Cardiovascular Care
ECS	Emergency Call Services
ERC	European Resuscitation Councils
ILCOR	International Liaison Committee on Resuscitation
LUCAS	Lund University Cardiac Assistance System
MI	Myocardial Infarction
NAS-NRC	National Research Council- National Academy of Sciences
PCI	Percutaneous coronary intervention
PEA	Pulseless Electrical Activity
SCD	Sudden cardiac death
SSC	Swedish Society of Cardiology

CONTENTS

INTRODUCTION

Cardiovascular diseases constitute approximately 40% of all causes of mortality in Europe of which ischemic heart disease plays the major part [1]. Most of those who die due to ischemic heart disease, die outside hospital of cardiac arrest. Out-of-hospital cardiac arrest is therefore considered to be a major factor of mortality in western countries [2, 3]. It has been estimated that approximately 10 000 people in Sweden die annually outside the hospital of cardiac arrest due to heart disease [4]. Due to deficient reporting, the true figure regarding the incidence of out-of-hospital cardiac arrest in the country is unattainable.

In the event of an out-of-hospital cardiac arrest, cardiopulmonary resuscitation (CPR) can save life, maintaining a small but necessary circulation until the arrival of the ambulance and /or further treatment possibilities such as arrival of a defibrillator with operator [5]. In spite of an ongoing work among international and national resuscitation councils to enhance survival rates after out-of-hospital cardiac arrests, this figure still is low - even if it varies greatly between different centres [6-12].

From a pedagogical perspective it is of interest to know how training programs in cardiopulmonary resuscitation influence practice, whereas from a strictly medical point of view, the interest is aimed mainly towards how practice influences the outcome, most often in terms of survival. As this area in medicine is dependent on the progress of knowledge in how to teach better learning of skills in resuscitation, a pedagogic interest has developed within this area. From this perspective there is a need to know what the most important facts are to teach and how to evaluate the outcome of training.

Using a pedagogical perspective, this thesis deals with accumulating knowledge to the incomplete puzzle of describing how well skills in cardiopulmonary resuscitation are retained, together with facilitating or hindering conditions for training and practice.

BACKGROUND

Cardiac arrest

Definition, etiology and incidence

Definition: "Cardiac arrest is the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness, and apnea (or agonal, gasping, respirations)" [13] (p. 961).

Most out-of-hospital cardiac arrests are judged to be of cardiac origin [4, 7-9, 14]. There is, however, a risk of over-estimating the proportion of arrests of cardiac origin if no autopsy is carried out for confirmation, as pointed out by Kuisma et al. [6]. In Helsinki, Finland, 67% of all cardiac arrests were of cardiac origin when verified by necropsy reports and hospital files.

The Swedish National Board of Health and Welfare [15] does not mention the proportion of cardiac arrest of cardiac origin occurring in Sweden. There is an indication that 90% of the cardiac arrests of cardiac origin are due to ischemic heart disease whilst the remaining 10% are due to other heart diseases such as valvular diseases or cardiomyopathy.

As the primary common cause of cardiac arrest is ischemic heart disease, the risk of suffering a cardiac arrest is higher among persons with prior coronary heart disease [16, 17]. The incidence varies between different groups of patients. One study in Seattle showed an incidence of out-of-hospital cardiac arrest in subjects with heart disease as 6/1000 subjects/year. In subjects without clinical heart disease this figure was 0.8/1000 subjects/year. Among patients who had a myocardial infarction or congestive heart failure the incidence was 14/1000 and 22/1000 subjects/year respectively [17].

In Denmark, 6676 consecutive patients with myocardial infarction who were admitted to hospital, were followed up to assess the risk for sudden cardiac death (SCD) or non-sudden death [18]. The result showed that the risk increased with increasing age, for both SCD and non-sudden death, although the risk for non-sudden death increases more with increasing age, the incidence of SCD being highest in the older age groups [18]. In Sweden, the median age of patients with an out-of-hospital cardiac arrest was 72 years in 2003 [4]. Out-of-hospital cardiac arrest is more common among men. The proportion of women who suffer from cardiac arrest increases with increasing age and was overall 29% during 2005 [4]. Despite the decrease of death rates in ischemic heart diseases, the mortality is still high in Europe [1, 3]. In the USA the decline in mortality due to ischemic heart disease was shown to be

mainly due to reduction in the in-hospital mortality while the out-of-hospital mortality reduction was far less [16].

Basic life support

Within the area of cardiac arrest, Basic Life Support encompasses the recognition of cardiac arrest, opening of airways and performing ventilations and chest compressions i.e. performance of CPR with no equipment. American Heart Association [19] defined the concept in year 1974 as follows:
"Basic Life Support is an emergency first aid procedure that consists of the recognition of airway obstruction, respiratory arrest, and the proper application of cardiopulmonary resuscitation (CPR). (p. 838)
In 1986 prevention of circulatory or respiratory arrest was added to the concept. Prevention should be obtained through prompt recognition and intervention and an early access to the emergency medical services [20].

An accurate application of CPR presupposes recognition of and correct diagnosis of cardiac arrest. There is, however, a lack of scientific evidence for lay peoples' ability to distinguish between respiratory arrests and cardiac arrests. It has been shown that pulse control is time consuming and difficult for both laypersons [21] and health care professionals [22] to perform correctly. In the international guidelines, teaching of pulse control was therefore eliminated for lay rescuers [23, 24]. It has been discussed whether bystanders could perceive occasional gasps as if the patient is breathing, which in turn could result in mistakenly withholding CPR. In Sweden this has led to the decision to continue the teaching of pulse control to lay people even though current European Resuscitation Guidelines recommend lay people to start CPR "*if a victim is unconscious (unresponsive) and not breathing* normally" [25] (p S12).

The history of Cardio-pulmonary resuscitation

CPR encompasses both mouth-to mouth ventilation and chest compressions. Mouth-to-mouth ventilation as the technique for artificial ventilation was used already in the 18th century but was later abandoned. In 1946, during the poliomyelitis epidemic when victims suffered from paralysis of the breathing muscles, this method was rediscovered. The American Medical Association endorsed mouth-to mouth ventilation as the technique for artificial ventilation in 1958 [26]. When mouth-to-mouth ventilation was combined with closed chest compressions in 1960, modern CPR was born even if the term CPR was used for the first time in 1962 [26].

Closed chest compressions were described for the first time as a method for emergency circulation by Boehm in 1878, as cited by Kouwenhoven *et al* [27]. It was rediscovered in the 1950's, and in 1960 Kouwenhoven showed the effectiveness of closed chest compressions as a method for artificial circulation on humans. After the invention of a closed chest defibrillator in 1957, Kouwenhoven and his co-workers discovered that 'return of spontaneous heart action' was unlikely to occur if the counter shock was not applied within less than three minutes. Closed chest compressions were therefore invented in order to extend the time in which defibrillation could be effective without opening the chest. Previously, the method of open chest cardiac massage was used, which limited resuscitation efforts to a very few patients. Closed chest compressions had a huge advantage compared to the open chest cardiac massage since it required no equipment at all. The only thing needed was the rescuers two hands [27].

The technique used by Kouwenhoven was very much the same as it is today, even if the explanation of why it works has been changed during subsequent years. Kouwenhoven's explanation was that circulation was obtained by chest compressions as the blood was forced out when the heart was compressed between the sternum and the vertebra. It was later shown by echocardiography, that the cardiac valves become ineffectual during resuscitation and that coughing alone could maintain circulation during ventricular fibrillation [28], facts which contradicted Kouwenhoven's theory. The mechanism behind circulation obtained by chest compressions ought therefore to be variations in the intra thoracic pressures. Even this theory has been modified by later studies, it seems as if both mechanisms work depending on the time elapsed during ongoing CPR [29]. The results from the study made by Ma *et al.* [29] indicate that it is the direct compression of the heart (= the heart pump), which causes flow in the early phase of CPR. When time elapses, the left ventricle and the mitral valve become increasingly stiff. When, due to stiffness, the mitral valve remains open, variations in the intra thoracic pressures play the dominant role as the flow inducing mechanism (= the chest pump).

Kouwenhoven also argued that closed chest compressions provided some ventilation of the lungs, so if only one person was present in the case of an arrest, this person should concentrate on the chest compressions only. Only if two or more persons were available, mouth-to-nose ventilations should be provided as well [27]. Recent studies have demonstrated the importance of more time to "flow generating activities" during resuscitation [30-34].

The history of CPR education

In the beginning, CPR was taught only to health care professionals. The first recommendations regarding CPR came at the National Academy of Sciences - National Research Council (NAS-NRC) conference in 1966 in the USA. The recommendations included medical, allied health, and other professional personnel to be trained in the external chest compression technique according to the standards of the American Heart Association (AHA). However, it was soon realized that training programs had to be extended to the general public. In 1973 AHA and NAS-NRC sponsored the National Conference on Standards for CPR and Emergency Cardiovascular Care (ECC), in which the recommendation came to include the general public in CPR training [35]. It was early recognised that there was a great need for these skills among certain groups in the society. The recommendation in 1973 therefore stated that the training should be started with specific need-groups such as *"policemen, firemen, lifeguards, rescue workers, high-risk-industry workers, and families of cardiac patients"* [35](p, 838). It should also be expanded to include training for school children and other sectors of the general public. In 1992 AHA recommended CPR training for relatives and close friends of persons at risk. This need was also reemphasised in the International Guidelines 2000 [36].

In Sweden the first CPR training programme, directed to both health care professionals and lay people, was conceived in 1984. It was developed by the Swedish Society of Cardiology's (SSC) working-group of CPR on the commission of the SSC. The American Heart Association course in USA served as a model in the development of the Swedish CPR training programme. Since 1985, when the first CPR training course took place, approximately 2.5 million people have been trained in CPR in Sweden [37]. Dissemination of knowledge and skills has been based on the cascade principle. Where main-instructors educate instructors, who in turn educate rescuers. For maintaining the quality of education the courses were standardized and for being allowed to teach, a formal training to be instructor was compulsory. Anyone with an interest in teaching and who are able to perform CPR properly can be educated and become certified instructor. Additionally, voluntary organisations such as the Swedish Red Cross and the Swedish Life Saving Society have also served as important actors in the dissemination of CPR knowledge in Sweden.

The SSC working group of CPR, which was reorganized and became the Swedish Resuscitation Council in year 2005, has been responsible for the development of courses since the beginning. The foundation for this development is scientific evidence, which has been mainly based on medical experience. International guidelines have guided the changes, even if some

exceptions have been made in Sweden e.g. retaining the pulse control in the teaching of lay people.

Factors of importance for survival and outcome after cardiac arrest

Survival after cardiac arrest due to heart disease has increased over the past decades in some parts of the world [6, 38]. In Sweden, survival rates have remained relatively unchanged. However, this fact needs to be viewed in relation to the increase in age among out-of-hospital cardiac arrest victims and to the fact that ventricular fibrillation as the first recorded rhythm has decreased [39].

Survival is normally defined as discharged alive from the hospital after resuscitation. Even if the neurological outcome is important, this outcome has seldom been reported. This has now, however, been included in the recent update [40] of the guidelines for uniform reporting of data from out-of-hospital cardiac arrest [13]. According to this update, discharge alive, together with the neurological outcome at discharge, is the absolute minimum required data regarding the outcome for continuous quality improvement [40]. In the event of an out-of-hospital cardiac arrest, the chances of survival depends on several factors.

Chain of survival

The 'chain of survival' concept was introduced in 1991 by Cummins [5]. The best chance of survival exists when the following sequence of events occur as rapidly as possible (Figure 1).

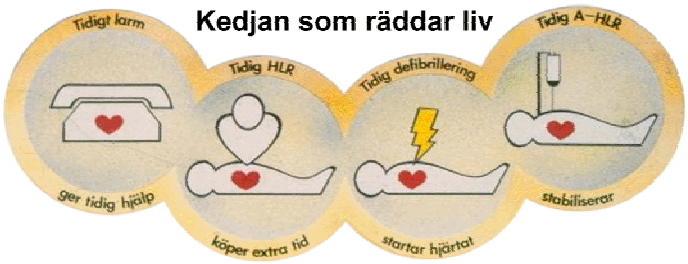

Figure 1. The 'chain of survival' adopted from the Swedish guidelines 2001

The first link in the chain of survival, early access, emphasises that the Emergency Call Services (ECS) must be alerted as quickly as possible. The second link, the early CPR link, emphasises that CPR should be started immediately after the cardiac arrest is recognized and the emergency medical services have been alerted. Bystander CPR is further described under a separate heading. The value of this link is to buy time for primary cardiac arrest patients by maintaining enough circulation to protect the brain and the heart from anoxic damage until defibrillation can be performed. These first two links are completely dependent on the layperson's ability to intervene in an out-of-hospital cardiac arrest. Early defibrillation constitutes the third link whilst the fourth link, early advanced CPR, includes intubation and medication.

The 'chain of survival' concept has often been used to search for weaknesses in the system in order to make improvements. Several studies have shown that it is possible to raise survival rates by strengthening the links in the 'chain of survival' [6, 11, 41-44]. To strengthen the first two links in the chain of survival, it is first of all necessary to educate lay people in recognizing early warnings signs of a cardiac event in order to call an ambulance before the cardiac arrest occurs. Whilst there is not always an early warning sign present [45], it is important to know what to do when the cardiac arrest has happened. In order to save lives, CPR training for lay people is therefore very important.

The location

The location of the cardiac arrest has been reported as an independent factor for survival [46-49]. Jackson and Swor found that patients who had suffered from their arrest witnessed outside their home, received bystander CPR nearly four times more often and were twice as likely to survive than those who suffered from a witnessed cardiac arrest at home [46]. Even if the proportion of patients with witnessed cardiac arrests at home who received bystander CPR have increased over the years in Sweden, this proportion is still lower than if the cardiac arrest occurs outside home (39% vs 60%, in 2001) [50, 51]. The reasons are debatable. One reason could be that the bystander is too old or is incapable of starting CPR. It has been shown that patients who experienced their cardiac arrest at home were older than those who had their arrest in other places [46, 48, 52].

Age, gender and co-morbidity

Figures from the Swedish Cardiac Arrest Registry show that the proportion of patients who received bystander CPR decreased with increasing age [53], which in turn reduced survival. In addition, older people are often afflicted by various diseases, which may also reduce survival as shown by Waalewijn *et al*. [45]. Patients with no medical history of cardiovascular disease had a better chance of surviving compared to those with a previous history of cardiovascular disease. The lowest chance of survival was among those patients who had a history of heart failure and diabetes [45].

Whilst age has, in some studies, also been found to be an independent factor associated with decreased chance of survival [6, 9, 49, 53], others have shown that the outcome after out-of-hospital arrest among the elderly is not universally futile. Swor *et al*. [54] found no difference in survival between those aged 60-69 and 70-79 compared to the reference group 50-59 years of age. The survival rates were eight and seven percent respectively, compared to 10% among those aged 50-59. Only in the age group of 80 and over, where the survival rate was four percent a significant reduction in survival was found [54]. Earlier Bonnin *et al*. [55] also found a survival rate of seven percent among victims over 70 years of age, and in those whose first recorded rhythm was ventricular tachycardia/ventricular fibrillation the survival was higher (14%).

Regarding survival in relation to gender, Fairbanks *et al.* [8] found no difference in survival between males and females. However, in studies covering considerably larger data material, females have been shown to survive to a higher degree than men [9, 56].

Cause of cardiac arrest and heart rhythm

Survival from cardiac arrest due to heart disease has been higher than survival from cardiac arrests due to other causes [57]. In a study by Waalewijn et al. [45], the foremost chance of survival was among those who had pre-arrest symptoms such as chest-pain or syncope/dizziness, as these were more likely to have ventricular fibrillation as the first recorded rhythm. This indicates that those patients probably had suffered from an acute myocardial infarction but the patients' final diagnoses were, however, not presented in the study.

Ventricular fibrillation as the first recorded rhythm after a cardiac arrest has, by many authors, been found to be associated with a better outcome [6, 49, 58-61]. The reason for this is partly due to the fact that it is possible to convert the arrhythmia to sinus rhythm by an early defibrillation, but also due

to the underlying mechanisms. The proportion of patients found in ventricular fibrillation decreases with the time elapsed between the cardiac arrest and the arrival of the ambulance [51, 62]. Since all cases of ventricular fibrillation deteriorate to asystole over time, a ventricular fibrillation could indicate a shorter time since the cardiac arrest started [62]. The incidence of cardiac arrests with ventricular fibrillation as the first recorded rhythm has shown a decreasing trend over the past decades in e.g. USA [63] and in Europe [11, 51, 64, 65]. The proportion of other rhythms, i.e. asystole and Pulseless Electrical Activity (PEA) has, therefore, increased even if the actual number of asystole and PEA did not increase [64]. The reason for the decrease of the proportion of patients found in ventricular fibrillation in out-of-hospital cardiac arrests has been discussed**.** There was a slight increase in response time in the Finnish study [64]. In the Swedish study there was also a slight increase in response time during the period 1991-2001 [51]. The response times may therefore have had some influence on the decrease in the occurrence of ventricular fibrillation as the first recorded rhythm, however the explanation is probably far more complex.

CPR

Bystander CPR

The definition of bystander CPR according to the recent update and simplification of the 1991 Utstein document [40] is as follows:

> "*Bystander CPR is CPR performed by a person who is not responding as a part of an organized emergency response system approach to a cardiac arrest. Physicians, nurses, and paramedics may be described as performing bystander CPR if they are not part of the emergency response system involved in the victim's resuscitation"* (p. 3387).

Thus, the bystander can be a layperson or in certain situations physicians, nurses or paramedics if they are on hand and off duty.

As most cardiac arrests occur outside the hospital and time is crucial, lay-bystanders can make a difference between life and death. If a bystander starts CPR, the chances of survival increase significantly [41, 49, 50, 58, 60, 66]. The odds ratio for improved survival after cardiac arrest has been shown to be 2-2,5 when a bystander starts CPR [49, 50, 58]. It has been shown that bystander CPR prolongs the time during which ventricular fibrillation persists and defibrillation may be successful [42, 60, 62, 67]. The earlier bystander CPR is started the better the outcome [68]. Therefore the need to promote more and improved CPR universally is urgent as stated in the International Liaison Committee on Resuscitation (ILCOR) Advisory Statement 2001 [69].

CPR training for families to cardiac care patients

In those cases when the cardiac arrest occurs in the patients' home, the persons most likely to witness this event are the family members, most often the spouse. The resuscitation councils therefore advocated early on that families of cardiac patients should be trained in CPR [35, 36]. This does not, however, seem to have been accomplished. Those trained are often younger persons who are not related to anyone likely to suffer from cardiac events [70, 71]. The reason for lack of CPR training among families to cardiac patients may be due to lack of effort in reaching this specific group, as patients or family members rarely receive a recommendation from health care professionals to attend a CPR course [72, 73]. Most people attend the CPR course due to job or school requirements and few due to the fact that they are living with someone with an increased risk of experiencing a cardiac arrest [71, 73]. To reach volunteers for CPR training in the community that are matching the risk groups by advertising, is a strategy which has been proved useful by Lester *et al*. [74].

There are some studies reporting CPR training for the target group [75-84]. In one of the early studies, Dracup *et al*. [76] found more anxiety among the patients when their family members had learned CPR. Later Dracup *et al*. [79] showed that combining the CPR training with social support led to better psychosocial adjustment and less anxiety among the patients. The patients were not involved in the training in any of the studies made by Dracup *et al*. [76, 79]. Among patients partaking in a cardiac rehabilitation programme, Ingram et al. [83] observed no significant differences in depression, anxiety or perceived control between those patients who participated in CPR training and those who did not. The benefit of CPR training for family members has also been shown to increase their perceived control [75] and reduce anxiety [82, 84]. However, being trained in CPR does not guarantee that a person starts CPR [52, 66, 85]. Swor *et al*.[85] showed that family members, even though they often witnessed the cardiac arrest, seldom started CPR even if they were trained in CPR. Panicking (38%), fear for not being able to perform CPR correctly (9%) and fear of hurting the patient (1%) or unwillingness to perform mouth-to-mouth ventilations (1%) were reasons described.

Quality of CPR

Ongoing circulation for as much of the time as possible is the ultimate prerequisite for good quality CPR. During recent years the necessity to minimize interruptions in chest compressions have attracted much attention

and finally the compression to ventilation ratio was changed to 30:2 in the International Guidelines in year 2005 [25].

Some early studies showed that the quality of CPR, in terms of deep enough chest compressions and ventilations, has a great influence on survival rates [86-88]. Performance of both adequate ventilation (with visible expansion of the chest wall during mouth-to-mouth ventilation) and compressions (with palpable carotid or femoral pulse during chest compressions), was regarded as good CPR in the study by Wik *et al*. [87], and by Gallagher *et al*. [88]. Patients who received CPR, which was regarded as inferior or not effective, had the same poor outcome as those who received no CPR. Moreover inadequate compressions did not improve survival even if the ventilation was adequate [88], and in those cases where only mouth-to-mouth ventilation was applied the survival was no better than if no CPR at all had been used [86, 88]. In those cases when CPR was performed effectively ventricular fibrillation was more common as the first recorded rhythm [86, 87]. Good CPR was applied in approximately half of the cases that received bystander CPR [86-88].

In a study by Holmberg *et al*. [68] the odds ratio for survival one month after the cardiac arrest was 4.9 if the bystander was a medical professional person, compared to 2.5 if the bystander was a layperson. In a subsequent study survival rates were compared between the group of patients who received bystander CPR by lay people and the group who received bystander CPR by a professional person. The result showed an adjusted odds ratio for survival of 1.3 (95% CI: 1.06-1.62) among patients who received bystander CPR from professionals. This indicates that medical professionals perform better CPR than lay people. In the study by Wik *et al*. [87], good CPR was performed less often by lay bystanders than by professional bystanders. Of the 70 patients who received good bystander CPR, 23% survived to hospital discharge compared to 1% of those who received inadequate bystander CPR.

The importance of learning good and effective CPR is obvious. As both skill acquisition and retention has been shown to be poor following CPR education in several countries [89-93], ILCOR stated that skills must be improved by better training methods and simplified procedures [69]. The ILCOR document also stated that existing and new training methods have to be evaluated by more specific and detailed measurements.

Various training methods and CPR performance

Ever since the start of the first Swedish CPR training programme, an instructor has taught CPR in three-hour courses. In the beginning one

manikin was used for a group of six to eight participants. In 1992 pair wise training was introduced with the use of one manikin for each pair of participants. This was introduced for enhancing hands-on training and making training more realistic. The idea was also to provide a better preparation for real life situations. Only single rescuer CPR has been trained at this level even though the same educational programme has been used for health care professionals.

The tradition of teaching CPR has been based on the instructor serving as a role model, not only in Sweden but also in most other countries. The requirement for instructors has been; to be able to perform CPR correctly, to provide enthusiasm and motivation. The pedagogic teaching and training for instructors has been limited to a course lasting only a few hours. As traditional instructor-led courses have been shown to often fail, resulting in adequate CPR performance [69, 91, 93-97], other pedagogic approaches have been tested. Instructors have been found to provide too much information leading to little time for practical training, omitting to correct mistakes and omitting to provide feedback. As the instructors were shown to be a weak link [69, 95], teaching methods that omits the instructor have been developed [98]. The use of video self-instruction with one manikin for each participant has lead to better skills in some studies [98-100] and no worse in others [101, 102]. The proportion of correctly performed chest compressions and ventilations were, however, low in the group that received video self instruction, even if it was clearly better than among those trained in traditional instructor-based courses in the study by Bacheller *et al.* [99]. Whilst there have been and still are ongoing needs for enhancing the skills of performance, other instructional methods have been tested.

The use of automated feedback during training has shown promising results with improved ventilation and compression skills even six months after training, when subjects trained repeatedly after the initial training [103, 104].

Another method for enhancing skills of performance tested earlier was staged teaching which involved three stages called bronze, silver and gold [96, 97, 105, 106]. In the first stage i.e. bronze the rescuers were taught; summons help, open airway and if no response - start with chest compressions without checking for pulse. After every set of 50 chest compressions a check of and opening of airways was taught. No ventilations were performed at this stage [105]. During this stage in the test, when a simplified technique for finding the compression position was used, it was shown that the main advantage with this method compared to conventional training was the huge difference regarding the number of chest compressions over time. Chest compressions

'too shallow' were common in both groups [96]. In the second stage "silver", ventilations were added and 50 chest compressions followed by five inflations were taught [107]. Those who attended this second training occasion performed better than those retrained in the conventional course regarding correct compression rate. However, participators in the conventional group performed ventilations correctly in a higher degree than those in the staged teaching group in this test. Prior to the third training none of these differences between groups remained in the test [107].

The Swedish Resuscitation Council adopted the principles of self-training and "training while watching" using personal manikins. Since November 2006 the Swedish educational programme encompasses a DVD-based training course with the use of personal manikins [108].

Various methods for evaluation

In the systematic work of describing quality of CPR performance, a number of methods have been used both for measurement of skills and for rating the individuals performances. In step with the development of new technology, new methods have been utilized.

Early on the use of printouts from recording manikins enabled objective measurements of chest compressions and ventilations. However for compiling the results in order to compare results between different groups, and to given guidelines, additionally instruments were needed. Berden *et al.* [109] introduced a scoring system with penalty points ranging from five to twenty depending on the seriousness of the mistakes made. Only mistakes regarding ventilations and chest compressions were assessed. Minor mistakes rendered five points. Mistakes that probably would result in failure to resuscitate rendered twenty penalty points (fatal mistake). A pass score of 15 penalty points was set i.e. three minor mistakes, or one minor and one moderate. This method was also used by Jansen *et al.* [89] in combination with a checklist to test general practitioners in their CPR skills. In conjunction with the checklist and penalty scored printouts, they performed a general impression rating. The checklist used entailed both the diagnostic procedures and CPR performance. They found poor correlation between the checklist and the score from the manikin recording prints. Additionally, the correlation between general impression and the scores of printouts was low. The observers did not identify poor performance regarding chest compressions and ventilations, and rated higher number of participants as performing adequate CPR. There was also a low correlation between scores of the diagnostic procedures and CPR performance. The authors therefore

recommended the use of a checklist for the diagnostic procedures and use of recording strips for evaluation of CPR performance.

Another standardised method used for evaluation of performance of "one rescuer CPR" was "the Cardiff Assessment of Response and Evaluation" (CARE) for measurements of the diagnostic procedure. This instrument was often used in combination with video recordings in combination with recording manikin printouts (VIDRAP) [92].The method to analyse printouts is time consuming and has the limitation that only a short period of the CPR performance is analyzable. When the Laerdal manikin Skillmeter Resusci Anne was introduced, it became possible to evaluate longer periods of CPR performance and receive a summary of committed errors. This manikin also included information on assessments of consciousness, opening of airways and pulse control. Nyman *et al.* [90] used the Skillmeter Rescusci Anne manikin with no checklist in the evaluation of CPR performance among nurses. However, many nurses performed the check for breathing before they opened the airway, which is not possible to detect on the screen. Combining Skillmeter measurements with a checklist makes, therefore, closer descriptions of performance possible.

Brennan *et al.* [110] developed a 14-item CPR checklist for the evaluation of skill performance together with an overall five scale rating. The first seven of the 14-items were according to earlier guidelines: 1) checks for unresponsiveness 2) calls for help 3) opens airway 4) checks breathing 5) attempts two breaths 6) checks the carotid pulse 7) locates compression position. The following items could, however, be measured by an instrumented manikin. All items were described in detail on how to be evaluated and a standardised evaluator script was supplied. Brennan recommended that the minimum set of data should include items 1-7 to be used this in connection with an instrumented manikin. The Brennan *et al.* checklist has been used in connection with the Skillmeter manikin in several studies [98, 99].

Since the development of the Laerdal SkillReporter system, the collecting of a large number of data has been facilitated. This system has been used in a number of recent studies [100, 101, 111]. The SkillReporter system does not, however, replace an observer for the first steps i.e. assessment of consciousness, breathing control and the alerting of the emergency system.

For evaluating more complex procedures e.g. the use of semiautomatic defibrillators, a checklist for objective observation has been developed in Finland, called Objective Structured Clinical Examination (OSCE). This

instrument has been used for assessing and comparing resuscitation skills between nurses working in two university hospitals in Finland and Sweden for the development of an educational programme [112].

RATIONALE FOR THE STUDY

Knowing the importance of CPR training among spouses and co-habitants to persons with various heart diseases, it seemed important to investigate the proportion of cardiac care patients living with a person who could be prepared to intervene in case of a cardiac arrest, i.e. trained in CPR. As a positive attitude towards CPR and CPR training ought to be a requirement for attending a CPR course, it also seemed important to investigate cardiac care patients' attitude towards such training.

As we know that the quality of CPR is crucial for survival it is important to assure the quality of performance. During the past years a variety of different scoring methods have been used in order to evaluate CPR skills. However, there is still a need for objective methods for measurement, which are simple to use. Testing new methods for objective measurements with respect to their ability to investigate skills of CPR performance in a detailed manner, is therefore of interest. In a pilot study nurses working at a coronary care unit were tested mainly to investigate the appropriateness of the method. These nurses are well trained and ought to perform good CPR.

Laypersons attending CPR courses in the regime of local Heart and Lung Associations could be representative for those most likely to witness out-of-hospital cardiac arrest and thereby forced to use their skills. Knowing that both skill attainment and retention have been poor among laypersons in other countries, we wanted to access how CPR skills were attained and retained over a short period of time in this group trained within the Swedish educational programme.

Knowing that family members are often witnesses to cardiac arrests and often omit starting CPR, even if they are trained in CPR, their experiences are important to describe. We wanted to gain a deeper understanding of how spouses witnessing cardiac arrest at home perceive and interpret this event and how they react and act. Using qualitative methods, the results are inductive - derived from the information given by the informants. This approach may make new insights possible.

AIMS OF THE STUDY

The overall aim with this thesis was to describe various aspects of CPR for finding approaches for enhancing bystander interventions. The interest was focused on cardiac care patients and their co-habitants.

This included the following aims:

- To investigate cardiac care patients' attitude towards CPR and interest in CPR education.

- To investigate the level of education in CPR training among cardiac care patients and their co-habitants and to describe the possibilities for, and obstacles to, CPR training among this group.

- To test a model of quality assurance, containing a computer program, combined with the Brennan *et al*. checklist, for evaluation of CPR performance.

- To investigate the quality of CPR performed on a manikin immediately after CPR training and three months later.

- To describe spouses' experiences during the cardiac arrest at home focusing on the time before the event and when it happened.

MATERIALS AND METHODS

Participants

The samples in this thesis derive from four different populations (Fig. 2). In study II and III, all patients admitted to the coronary care unit during a four-month period (September 15- December 14, 2000 and January 15 - February 15, 2001) were considered for participation (for further details see Paper II). Of the 473 patients invited to participate in the study, 401 accepted (**Paper II**). **Paper III** deals with those who were co-habiting among the 401 patients (n= 268) (Fig. 2).

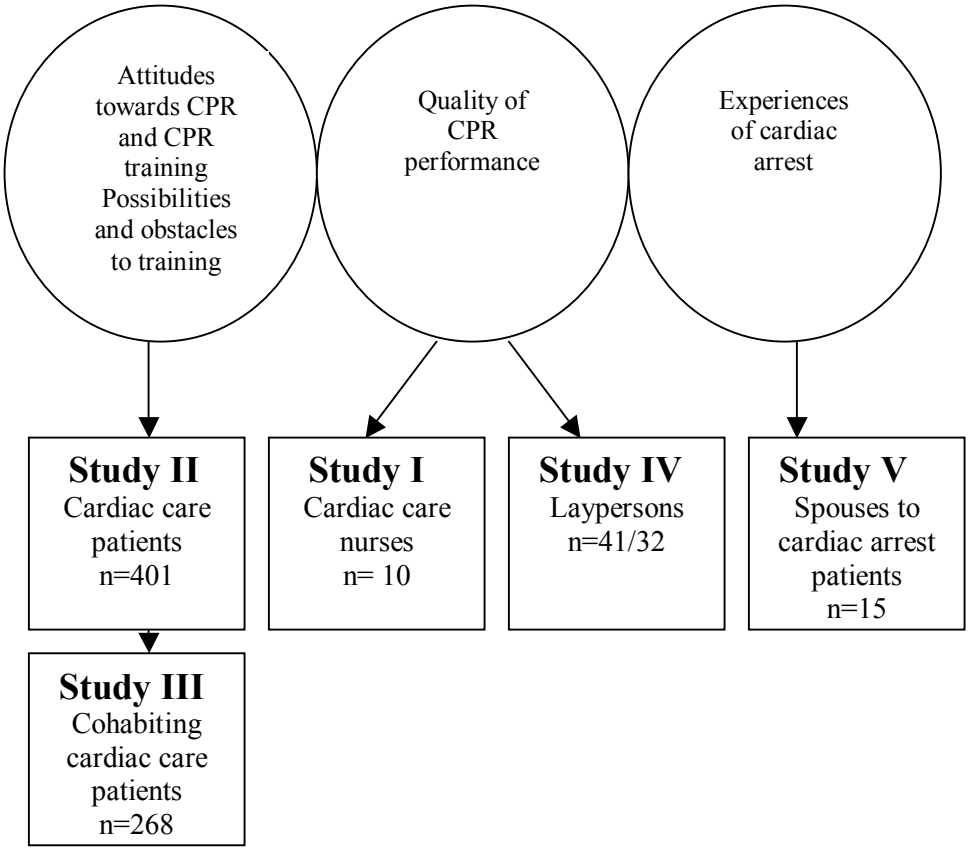

Figure 2. Studied areas and their included participants

A suitable sample of 10 nurses and enrolled nurses were included in study I. They were all working in a coronary care unit at a Swedish university hospital. Those who were eligible worked during the two days in February 1999 when the study was carried out. In the following, all participants in this study (**Paper I**) are called nurses.

The quality of CPR performance was studied in this group (**Paper I**) and among laypersons who attended a CPR course in the regime of a local Heart and Lung Association (**Paper IV**). Among 55 participating in the courses, 41 were willing to participate in the study and were tested after training. Three months later, 32 participants returned for the second test (Fig. 2). The study was conducted between January 2004 and June 2006.

For describing spouses' experiences when the cardiac arrest occurred at home (**Paper V**), fifteen spouses or co-habitants (in the following called spouses) were interviewed. Spouses, who had been present when the cardiac arrest took place in January 2004 and the time following, were considered for participation. The inclusion processes started in April 2006 and proceeded until the desirable number of participants was reached in January 2007. The patients were identified via the Swedish Cardiac Arrest Register. A total of 85 patients below the age of 80 years were brought to the Sahlgrenska University hospital during the period 2004-01-01 until 2006-03-21 after suffering a witnessed cardiac arrest at home of probable cardiac cause. The medical records for these patients were examined and in 36 of these cases it was possible to identify the name, address and telephone number for the spouse who had been the witness. A prerequisite of participation was to be able to speak and understand the Swedish language. Of the 36 spouses invited to participate in the study three were not possible to reach by telephone and 18 declined participation.

Data collection and procedure

Attitudes towards CPR and CPR training, possibilities and obstacles to training; Paper II and III

To obtain information on the patients' previous medical history, a form was developed. The form was designed to obtain information on any previous history of myocardial infarction, angina pectoris, any coronary intervention procedure (CABG or PCI), hypertension, heart failure, diabetes mellitus, cerebral infarction, intermittent claudiocation, previous cardiac arrest, cancer or any chronic disease. Data collection for this form was based on interviews in combination with assessment of the medical records.

To investigate the patients' attitude towards CPR and interest in CPR education, a questionnaire was developed (**Paper II**). This questionnaire contained questions regarding the patients' knowledge of the concept CPR and if they would like someone to start CPR on them in case of an emergency (3 questions). It also contained questions regarding their awareness and attitude towards CPR education (16 questions) (further details see **Paper II**).

Above-mentioned questionnaire also contained questions only targeted to those who were co-habiting in order to investigate the proportion of patients and co-habitants trained in CPR, together with the possibilities for, and obstacles to, CPR training among this group (**Paper III**). Beside questions regarding the patient's knowledge, level of education in CPR training and willingness to participate in CPR training, this part contained questions regarding the co-habitants level of training. Questions regarding the patients' willingness to attend a course together with their co-habitant were also put together with questions relating to possible obstacles for such training. In total this part consisted of 14 questions (for further details see **Paper III**).

Patients were interviewed during their period of hospitalisation. The participants were given the opportunity to initiate discussions concerning their thoughts and feelings of the subject under investigation. The duration of the interview, therefore, varied between half an hour and over one hour.

Quality of CPR performance; Paper I and IV

In an unannounced test, participants (**Paper I**) were asked to take part in an evaluation of CPR education. In **Paper IV** participants were tested immediately after the CPR training course and three months later. On all test occasions, participants were told that this was meant to be a realistic emergency. They were asked to do whatever they thought was needed in order to save the victims life. They were not explicitly asked to perform CPR. All participants were given the same information before evaluation. The information used was a translated form of the Brennan *et al*. [110] information. During evaluation no directions or information was given. The Laerdal Skillmeter Resusci Anne™ (**Paper I)** and the Laerdal Resusci Anne SkillReporter manikin (**Paper IV**) connected to a laptop computer with special software, was used as a victim.

Checklist

As a tool to evaluate the examination skills and to ensure the correct sequence up to initiation of CPR, the short version of the Brennan *et al*. [110] checklist was used. This checklist describes the steps, which are not reported

or incompletely reported by the instrumented manikin. The checklist was adjusted to the Swedish educational programme (Appendix). When the participants examined the victim, the checklist was used to code the examination skills (0= not performed, performed incorrectly, or performed out of sequence. 1= performed as described). This result was summarised to make a checklist performance scale, with a possible range from zero to seven points.

Test equipment

An instrumented manikin was used in both studies. In **Paper I** a Laerdal Skillmeter Resusci Ann ™ manikin was used. Due to the development of the computer software used in connection with the manikin, a later version of Laerdal manikins was used in **Paper IV** i.e. the Laerdal SkillReporter manikin.

A variable resistor in the Laerdal Skillmeter Resusci Ann ™ manikin (**Paper I**), measuring the rise of the chest wall, measured the inflation volume. The inflation volume divided by the time for inflation calculates 'flow rate'. To measure the compression depth, a variable resistor similar to the one for measuring inflation volume is used. In the Laerdal SkillReporter manikin (**Paper IV**) the measurements are digital. Two optical-encoders are used; one for measuring the rise of chest wall and one for measuring the chest wall displacement during chest compression. These sensors generate digital signals to the main processor in the manikin for translation to mm and ml. These data are then sent to the SkillReporter programme for statistical calculations.

Measurement uncertainty

The measurement uncertainty is the same for the two manikins. Regarding parameters concerning time and number results are very precise and measurement uncertainty is, in praxis, of no importance, whilst the parameter's compression depth and inflation volume have a tolerance of ±15% at delivery from Laerdal;

Ventilation parameters:	average inflation volume ±15%	
	Flow rate ±15%	
	Inflation minute volume ±15%	
Compression	parameters:	average compression depth ±15%
		Minute compression depth ±15%

Concerning compression depth, the SkillReporter manikin has a tendency to underestimate, which has been compensated for in the version from 2007. The degree of this underestimation lies precisely within the limits of ±15% in the depth 38 mm and reduces gradually in depths ≥38mm.

Computer software

The software, specially designed by Laerdal for evaluation of CPR skills, was connected to a Laerdal Skillmeter Resusci Ann ™ (**Paper I**). The software contains the usual parameters measured by a Laerdal Skillmeter Resusci Anne™: session duration for the CPR event (measured in seconds), number of inflations and chest compressions done together with the percentage of correct inflations and chest compressions according to European Resuscitation Councils (ERC) standards 1992 [113]. Mistakes, if any, are also reported. The inflation volume and flow rate regarding each ventilation are measured but not shown on the Skillmeter screen. From these parameters, the computer calculates the following new parameters; average number of inflations per minute and, 'Inflation minute volume'. Concerning chest compressions; average number of compressions per minute and 'Minute compression depth' are measured and calculated by the computer. In **Paper IV** we used a commercial version of this software; Laerdal SkillReporting System, in connection with a SkillReporter manikin. The ERC guidelines 2000 [24] were used in the programme.

The number of ventilations per minute is measured from the first ventilation to the last in the SkillReporter programme. Likewise, the number of chest compressions per minute is measured from the first chest compression to the last chest compression. In the earlier version i.e. the Skillmeter, the measurement of the number of ventilations and chest compressions is based on the time from 'CPR started to CPR stopped', which is defined as the time from the first compression or ventilation to the last compression or ventilation. Therefore the results from the Skillmeter version may differ from those measured by the SkillReporting system.

Experiences of cardiac arrest; Paper V

Interview

The spouses were interviewed 10-27 months (median 22 months) after the cardiac arrest event. To gain a deeper understanding of spouses' experiences during a cardiac arrest at home, personal interviews face-to-face were conducted. The participants' narrative of their experiences was initiated with the question; can you please tell me as detailed as possible, what happened?

Thereafter the principles for being a good listener and confirming the interviewee were paramount for the interviewer. This included a critical careful control that the true meaning of what they said was correctly understood while listening between the lines for implicit messages [114]. The interviewees were encouraged to freely narrate their story. Probing questions were asked to assure that the spouses' experiences were properly elucidated. An interview guide was used to assure they all covered the same content areas. Perceptions, thoughts and feelings, reactions and actions during the event were focused on.

A digital recorder was used. The interviews were transcribed verbatim and edited for accuracy. Before the systematic process of analysis started all interviews were performed and transcribed.

Two pilot interviews were made for test of questions prior to start of the study. As these informants were not a part of the inclusion process as described above, these interviews were not included in the study.

Data analysis

Statistics

In **Paper I** no statistical calculations were performed. **In Paper II** Pitman's non-parametric permutation test was used to evaluate willingness to undergo CPR with regard to various characteristics and disease situations. The Chi-square test was used for comparisons between men and women and between age groups regarding willingness to attend CPR training in **Paper III**. In the comparisons the alternatives in the variable were dichotomized to "yes and unsure/no". An estimation of the Odds Ratio regarding willingness to attend a CPR course with reference to age was also performed.

In **Paper II** and **III** responses, which did not fit into the pre-formulated alternatives, were classified under 'other'. Similar responses were grouped together and frequencies were counted.

To determine differences between participants attending both tests and those who did not return to test number two, regarding discrete variables (sex and co-habiting or not) Fisher's Exact Test was used in **Paper IV**. Regarding continuous and ordered variables (age, number of previous courses and proportion of correctly performed ventilations and chest compressions) the Mann-Whitney U test was used. In the evaluation of differences within the group regarding skills in test number one and two the Wilcoxson Sign Rank test was used in **Paper IV**.

All *p*-values were two-tailed and considered as significant if less than 0.05. A summary of the statistical analysis is presented in Table 1.

Table 1. Statistical analysis used in Paper II-IV

	Paper number
Comparison between groups	
Pitman's non-parametric permutation test	**II**
Chi-square test	**III**
Odds Ratio	**III**
Fisher's Exact Test	**IV**
Mann-Whitney U test	**IV**
Comparison within the group	
The Wilcoxson Sign Rank test	**IV**

" Not everything that can be counted counts, and not everything that counts can be counted"

- Albert Einstein as cited by Patton [115] page 12

Qualitative content analysis

Qualitative content analysis was used in the analysis of interviews. Content analysis has been used in many different ways. Early on when used for analysis of texts for e.g. mass media and propaganda analysis, the analysis consisted of calculation of the number of times certain words, concepts or content appeared in the text. In the beginning, content analysis was developed from the positivistic tradition and the logical empiricism. Patton [115] describes the logical empiricism's idea of knowledge viewed as correct representation of an independent reality. From that quantitative, positivistic tradition there has also been a shift towards the hermeneutic tradition with more interpretative, qualitative analysis of texts focusing more on meanings than on superficial features. In this tradition the interpretation can never claim to be the truth. There may be other possible alternatives to interpret a text but all possibilities are not equally credible.

According to Krippendorff [116] the content emerges in the process of a researcher analyzing a text relative to a particular context. Krippendorff argues that there is always an element of interpretation involved when

reading and analysing a text, even in those cases when the analysis ends up in calculations and numbers. Additionally, Krippendorff argues there is no single meaning waiting to be "found" and "described" in a text. Instead all texts can be read from different perspectives and understood within a certain context. Inferences drawn from texts depend on the context of its use i.e. what the text means to particular users [116]. The intention was to capture the spouses' experiences. As the knowledge of spouses' experiences is important in the context of CPR education the text is understood within this context.

The analysis process started with reading the transcribed interviews repeatedly until a grasp of the whole was obtained. Thereafter all text was brought together to one document and a thoroughgoing reading was made with the research questions and aim of the study in mind. At the same time, striving for openness of the unexpected was pursued. Text referring to the spouses' experiences was divided into meaning units i.e. words or sentences relating to the same central meaning. The meaning units were then condensed i.e. shortened, while preserving the core meaning. The condensed meaning units were labelled with codes often by using key words in the text. During this process the whole context of the interview was considered. An example of the analysis is presented in Table 2.

Table 2. Example of analysis; condensed meaning unit, codes and preliminary themes

Text	Condensed meaning unit	Code	Preliminary theme
IP4: Then I went to the bed and looked, he had fallen out of the bed towards the window and the bedside table which he probably hit because he had a little scratch on the forehead which I saw, and then I got really scared	Saw he had fallen out of bed and hit himself got really scared	Fallen out of bed Got really scared	Interpreted signs as serious
Then I said Eric, Erik! I only screamed and he didn't say a word but it rattled something like that and I thought he was dead, I nearly thought that in fact because I thought it sounded scary	I screamed he didn't say a word but it rattled. Nearly thought he was dead because it sounded scary	Called out Thought he was dead	Interpreted signs as serious
…..Interviewer: You said she asked you.. IP4: yes she asked if I could, I don't remember, I remember she asked if I could do mouth to mouth ventilation or if I could see if he was breathing and then I said I can't I am eighty five years old so I can't. Yes, yes we are coming she said	She asked if I could perform ventilations or see if he was breathing. I can't I am old	Got the question Can not help	Being unable to help

Thereafter the text was divided into three different time domains; 1) the time before the cardiac arrest; 2) the cardiac arrest event; 3) the third domain the time after the cardiac arrest was left for a coming analysis and will be presented elsewhere. For facilitating the analysis it has been advocated by Krippendorff to divide huge amounts of texts into smaller areas [116].

After dividing the text into the domains, two and, to some extent, three of the authors, in collaboration, made the analysis. The labels for the codes were discussed until consensus was reached when codes emerged that covered several meaning units. The codes were compared based on similarities and variations throughout the analysis. For making the events clearer and allowing themes to emerge more easily, the codes for each interview were put together chronologically as the event was described to have happened. The codes were coloured to distinguish between different kinds of codes i.e. codes referring to perceptions, thoughts, feelings and measures taken. Codes referring to bodily or psychic symptoms and signs together with codes for signs that were perceived as ordinary or serious were marked with different colours. Finally, four themes in the first domain and three themes in the second domain emerged in this process.

ETHICAL CONSIDERATIONS

Approval was obtained by the Committee for Ethics in Medical Investigations at the University of Göteborg (reference no. S 273-00) regarding **Paper II** and **III**. Prior to the start of the study, contact was made to the Ethical Forum at Sahlgrenska University Hospital and one of their counsellors promised to be on hand if patients needed to talk to someone not involved in the study.

To ask cardiac care patients about their awareness and attitude towards CPR and CPR education could increase the patient's awareness of the risk of suffering a serious complication and thereby causing increased anxiety. We tried to reduce this risk by establishing a good relationship with the patient and listening to the patients expressing his/her thoughts. It was, however, quite possible that the patients already harboured fears regarding serious complications that needed to be expressed. Many patients raised the issue of receiving CPR themselves stating that it is vital that as many people as possible are trained in CPR. In those cases when the interviewer was uncertain of the patient's psychological ability to deal with the question of whether they would like someone to start CPR on them in the event of an emergency, the question was abandoned. This accounts for the 54 missing responses to this question.

The test of the model for quality assurance was regarded by the Committee for Ethics in Medical Investigations as a quality control. The committee therefore waived the need for approval (**Paper I**). Likewise the committee waived the need for approval concerning the evaluation of CPR performance and retention after CPR training (**Paper IV**).

For the interview study (**Paper V**) approval was obtained by the Committee for Ethics in Medical Investigations at the University of Göteborg in January 2003 (reference no: S 299-02). To narrate ones experiences in connection with loved ones suffering from cardiac arrest at home could cause increased stress. Feelings of guilt could be present or could be induced by insensitiveness when asking questions. We tried to avoid this by using their narrative as a starting point in the questions and confirming their feelings in a difficult situation. After the interview, time was spent to allow feelings to be expressed and to ensure they could handle the situation. In agreement with the counsellors at the emergency department and the intensive care units at the hospital, they agreed to be on hand in case of the need for a follow-up.

RESULTS

Cardiac care patients' awareness and attitude towards CPR and CPR courses (Paper II)

The investigation resulted in 401 interviews with 274 males and 127 females. The mean age was 65 years (64 years for males and 68 years for females). Baseline characteristics and previous medical history are presented in Table 3. Most participants had heard about the concept of CPR (91%) even if not all were familiar with its meaning. Seventy-nine percent of the participants knew about inflations while 69% had some knowledge of external chest compressions and 64% knew about both of these components.

The willingness to undergo CPR in a case of an emergency varied (Table 4), even if most of the participants were positive (96%). Those over the median 67 years of age were less willing to undergo CPR than those who were younger (p=0.02). Those who had had a previous myocardial infarction or heart failure were less willing to undergo CPR than those who had not (p=0.03 and 0.007 respectively). A medical history of cancer was not associated with the patients' willingness to undergo CPR, whilst the significance of previous cardiac arrest could not be estimated due to the small number of participants in the group. Due to small number of participants in each of the groups regarding various chronic diseases we used "any chronic disease".

Among all participants, 68% knew about the availability of CPR courses for the general public and 9% had at some point in time received information about CPR from a medical professional. The proportion of participants who had received CPR training was 40%. Of those who had been trained, 11% were trained within the last two years. The most common reason for CPR training was a compulsory course at work, followed by "general interest" and "other reasons". A small proportion (9%) stated his or her own or a friends cardiac condition as the reason for attending the course.

Among those with no CPR training (n=234) or unsure as to whether they had received such training (n=5), the reasons for lack of educated in CPR varied (Table 5). Half of these were interested in attending a CPR course.

Table 3. Baseline characteristics and previous medical history (*n*=401)

		%
Age	Years	
	<65	45
	65-75	24
	>75	31
Living arrangement:		
	Living alone	33
	Living with a family member	67
Medical history:		
	Myocardial infarction	32
	Heart failure, previous hospitalisation	16
	Cancer	12
	Cardiac arrest	3
	Any chronic disease	25

Table 4. Willingness to undergo CPR in relation to various characteristics (*n*=347, 54 missing)

	Yes %	Unsure %	No %	*p*-value*
Age:				0.02
≤67	99	<1	0	
≥68	93	4	3	
Gender:				NS
Male	98	1	1	
Female	92	5	3	
Previous Myocardial Infarction: †				0.03
With	92	4	4	
Without	98	1	1	
Previous hospitalisation due to heart failure: ‡				0.007
With	87	7	5	
Without	98	1	1	
Cancer: §				NS
With	93	2	5	
Without	96	2	1	
Cardiac arrest: ‖				
With	100	0	0	
Without	96	2	2	
Any chronic disease:				NS
With	95	2	3	
Without	97	2	1	

* NS:p≥0.05
† Six missing
‡ Ten missing
§ Two missing
‖ Seven missing and *p*-value not estimated due to small number

Table 5. Reasons for lack of CPR training (*n*=239)

Reason*	*n*	%
Did not know where to go	4	2
Did not know such courses existed	57	24
Intended to attend a course but have not yet done so	33	14
CPR courses on offer were too expensive	0	0
No interest in such training	36	15
Unable to manage	14	6
Other reason: †	103	43
"never thought about it"	*58*	
"lack of time"	*17*	
"lack of earlier motivation"	*9*	

* One or more reason
† The most common other reason

Prevalence of CPR training among co-habitants (Paper III)

In all, 268 of the participants were living with a family member. In order to investigate whether the co-habitant person had received CPR training, we asked the participants if their wife/husband or co-habitant had training in CPR. According to the answers given by the participants, 33% of the family members had undergone CPR training, 67% were unsure or did not believe he or she had undergone such training. Of those who were unsure or did not believe their co-habitant had trained CPR, 60% wanted her or him to attend such a course.

Interest in CPR education (Paper II and III)

Among all participants with no previous CPR training or unsure as to whether they had undergone such training, 46% stated that they would like to attend a CPR course while 20% were unsure (**Paper II**). Of those patients who were co-habiting and not trained in CPR (n=146), 58% were willing to attend a course while 16% were unsure (**Paper III**). Sixty percent of the participants who were unsure or stated that their co-habitant were not trained in CPR, were in favour of he/she attending such a course. Of the participants who had previously attended a course or who were willing to undergo training, 72% were prepared to do so together with their co-habitant (Table 6). A course specially designed for cardiac patients and their relatives was a possible alternative for 75% of those willing to participate together with their co-habitant.

Table 6. Interest on the part of those willing to be trained, or already trained, in participating in a CPR training course with co-habitants

	Yes %	Unsure %	No %
Would you like to attend a CPR course together with your wife/husband or cohabiting person? (n=198, 8 missing)	72	7	22
If Yes: Would you like to participate in a CPR training specifically designed for people with heart conditions and their relatives? (n=119, 23 missing)	75	13	13

The preferred location for the course was most often a hospital (40%) (**Paper II**). According to comments by these participants, professionals should hold the course because they would offer a better education and/or offer a safer environment. Of those who preferred the primary health care centres (25%), a common comment was that it was due to its location in the vicinity to the patients' home. For 20% of the participants the location did not matter.

Obstacles to training (Paper III)

The major obstacle to CPR training was the participant's own medical status. Regarding the co-habitant's participation, the major obstacle was doubts concerning the co-habitants physical ability or willingness to participate. Older participants were less willing to undergo CPR training than the younger ones ($p<0.0001$, OR 5.3, 95% CI 2.5-11.4). Among the participants over 66 years or older, 43% were willing to participate in a CPR training course compared to 80% of those who were aged 65 (median) or less. Fifty percent of the women compared to 60% of the men were willing to undergo CPR training (ns).

Of the participants interested in attending a CPR course together with their wife/husband or cohabitant person, 25% were unsure or unwilling to participate in a course specifically designed for people with heart conditions

and their relatives (Table 6). The following motives were mentioned; do not want to be associated with the disease, fear of too much discussion about diseases, and fear that someone will suffer a heart attack during the course. Some exhibited a resistance to participate in such a course together with other people with heart conditions and their relatives, but were unable to explain why. The preference for attending a course with healthy people was expressed by some of the participants'.

Evaluation of CPR performance and quality of CPR (Paper I and IV)

The first study (**Paper I**) focused on the use of a checklist in combination with an instrumented manikin connected to a software programme as an instrument for evaluation of CPR performance for quality assurance. In **Paper IV** the study focused on CPR performance among one group of people who may have an increased risk of witnessing a cardiac arrest. The results showed that immediately after training, the majority of the participating laypersons performed most of the examination skills as prescribed, except for calling for help. Three months later the participants to a lesser degree performed the check for unresponsiveness, opening of airways, check for breathing, the two initial breaths and the location of the compression position. The opening of airways was also a point of concern among the participating nurses (**Paper I**). Four of the ten nurses (**Paper I**), and five (16%) of those laypersons tested three months after training (**Paper IV**) checked the breathing as prescribed. Although eight participants (**Paper I**) checked the location of the compression position before they started chest compressions, few of them managed to find the right position. In **Paper I**, three participants of the 10, made all examinations as prescribed and reached seven points, whereas the rest of the participants either missed performing part of the examination or made incorrect assessments (median 5 points). The maximum number of points reached among the laypersons (**Paper IV**) three months after training was six points (median 2 points). Results according to checklist are presented in Fig. 3.

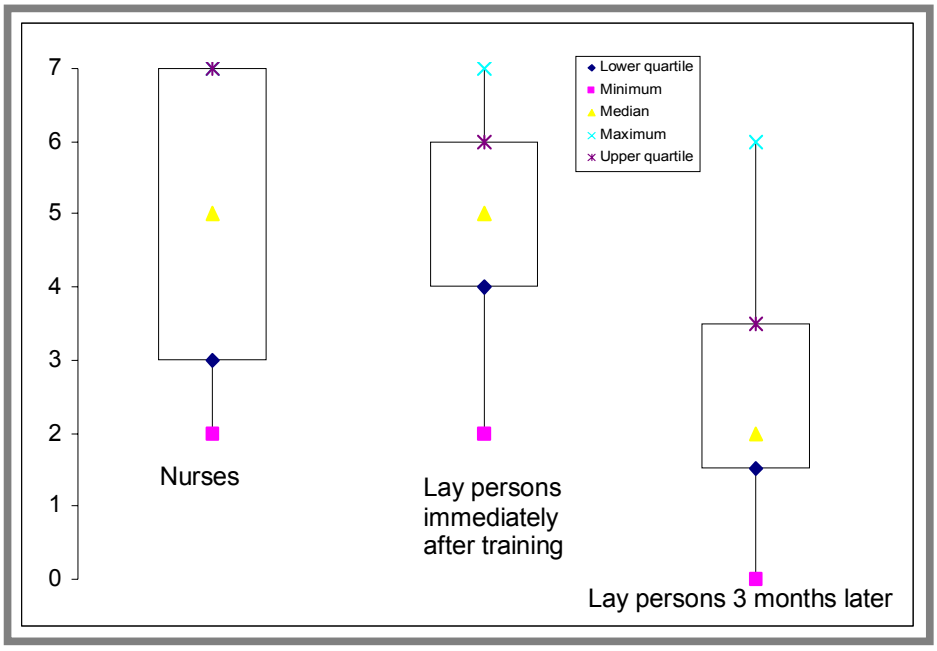

Figure 3. Checklist performance scale among nurses (**Paper I**, n=10) and lay people immediately after training and three months later (**Paper IV**, n=32)

In the performance of chest compressions among the nurses in **Paper I,** the average compression depth varied from 40 to 54 mm (mean 47 ±5). According to international guidelines chest compression depth should be 38-51 mm. The actual number of compressions during one minute varied from 32 to 51 (mean 41.3 ±6) (Table 7). Among the participating laypersons (**Paper IV**) the average compression depth was significantly reduced from 42 ±6 to 38 ±8 mm at the three months test (Table 7). The mean proportion of correctly performed chest compressions was reduced from 60% after training to 16% three months after training (p<0.0001). Chest compressions with incorrect hand position, most often 'too low' and compressions 'too shallow' constitute the majority of committed errors among laypersons (**Paper IV**). Among the nurses (**Paper I**) committed errors were mainly due to chest compressions 'too deep' and 'too low'.

Table 7. Performance of chest compressions among participants in **Paper I** (n=10), and **Paper IV** (n=32) after training and three months later. Integer numbers are presented.

	Nurses		Lay people; after training		Lay people: after three months	
	Mean (SD)	Median (min, max)	Mean (SD)	Median (min, max)	Mean (SD)	Median (min, max)
Chest compression rate	95 (18)	94 (72, 129)	84 (26)	80 (35,151)	78 (22)*	78 (37,136)*
Chest compressions per minute†	41 (6)	42 (32, 51)	37 (11)	38 (7, 61)	36 (10)*	34 (20, 57)*
Chest compression depth (mm)	47 (5)	47 (40, 54)	42 (6)	42 (29, 53)	38 (8)*	38 (27, 51)*
Proportion correctly performed (%)	30 (25)	31 (1-72)	60 (33)	67 (0, 100)	16 (26)	3 (0, 93)

* Three missing due to compressions too low to be registered by the manikin
† Measurement of this variable is performed slightly different in **Paper I** compared to **Paper IV**, see method section.

In **Paper I** half of the participants started with chest compressions without performing the initial two breaths. The number of ventilations per minute and proportion of ventilations correctly performed are presented in Table 8. Only two of the participants performed any inflation correctly. Inflations 'too fast' (>600 ml/second, 91% of all ventilations) and 'too much' (>1200 ml, 71%) constitute the majority of committed errors.

In **Paper IV** the participants made five inflations on average per minute immediately after training (Table 8). Three months after training the number of ventilations per minute was significantly reduced to three. Twelve of the participants failed to ventilate the manikin at all, most often due to omission in opening of airways (11 cases). The proportion of correctly performed ventilations was regarded as 0% among those participants. The mean

proportion of correctly performed ventilations was not significantly reduced. Committed errors were: insufficient volume (<700 ml, 38%), excessive volume (>1000 ml, 28%) and 'too fast' ventilations (>500 ml/second, 28%), after three months.

Table 8. Number of ventilations and proportion of correctly performed ventilations among participants in **Paper I** (n=10), and **Paper IV** (n=32). Integer numbers are presented

	Nurses		Lay people after training		Lay people after three months	
	Mean (SD)	Median (min, max)	Mean (SD)	Median (min, max)	Mean (SD	Median (min, max)
Ventilations per minute *	5 (2)	6 (0, 7)	5 (2)	5 (0, 8)	3 (3)	2 (0, 9)
Ventilations correctly performed %	6 (16)	0 (0, 53)	17 (19)	12 (0, 62)	15 (22)	0 (0, 67)

* This variable is measured slightly different in **Paper I** compared to **Paper IV,** see method section**.**

Experiences of cardiac arrest (Paper V)

During the interview the spouses often spontaneously talked about if they had had any previous CPR training. Among those who did not spontaneously raise the subject, they were asked. We have, therefore, information on any previous training for all the spouses. However, the time since training was not mentioned nor asked for, among all spouses. All spouses with previous CPR training, who were offered guidance from the Emergency Call Services (ECS) accepted the guidance. However, in one of these cases the spouse did not have the time to start because the ambulance arrived too quickly. Out of those with previous CPR training one spouse started CPR, with guidance being offered later. Additionally one spouse who was advised to place her husband in recovery position, called a neighbour who started CPR.

Among the spouses with no previous CPR training, four were offered and three accepted the guidance. Characteristics of the bystander spouses and measures taken are presented in Table 9.

Table 9. Age, previous CPR training and measures taken by the bystander spouse

	Male n=3	Female n=12
Age *years* Median (min, max)	74 (64,78)	67 (48, 87)
Previous CPR training	1	5
Offered guidance from ECS*	2	6
Accepted guidance from ECS	2	5
Performed CPR	1†	7‡

* In two cases the spouse made the call before the cardiac arrest happened
† In one further case ambulance arrived too quickly (before the spouse had the time to start CPR)
‡ One of these spouses called a neighbour who performed CPR

All spouses started their narration of the event by relating the time preceding the cardiac arrest, forming thereby the first domain *"The time before the cardiac arrest"* in the qualitative content analysis. In this domain four themes emerged in the analysis process; *"Lack of early warning signs", "Difficulties in interpreting early warning signs", "Interpret signs in light of earlier illness"* and *"Denial of serious illness"*. The time when the cardiac arrest happened formed a second domain *"The cardiac arrest event"*, in which three themes emerged in analysis; "*Perceiving the seriousness", "To be without the possibility to influence"* and *"To do what is in ones power*".

The time before cardiac arrest

Often there were no signs prior to the event that could have warned the spouse, which led to the theme *"Lack of early warning signs"*. The spouse had no chance to call for the ambulance earlier as everything had seemed completely normal. The spouse and the patient had been doing usual things or talking about ordinary things or the patient had been joking just before it happened. Some of the spouses described that the patient had pain in one or both arms a few seconds before the cardiac arrest.

In other cases there were signs present that were either diffuse or more specific leading to the theme "*Difficulties in interpreting early warning signs"*. The patient seemed as if he was feeling unwell or expressed that this was the case without giving a further description of what was the trouble. Other signs noted were e.g. signs of absent-mindedness, uncertainty, irritation and dizziness. These signs were sometimes interpreted as normal or in other cases leaving the spouse with no idea of how to interpret signs noted. In one of these cases, the patient had had a myocardial infarction one week before the cardiac arrest and had been restless and irritated hours before the event. He also had seemed to have unpleasant feelings and dizziness. In other cases signs noted were misinterpreted as due to an earlier illness leading to the theme *"Interpret signs in light of earlier illness"*. In those cases old strategies were often used even if they were ineffective. Abdominal pain hours before the event, the patient feeling unwell and tiredness were signs interpreted as due to earlier illness. In some cases there were also indications of denial from both the patients' and the spouses' point of view, which formed the theme *"Denial of serious illness"*. Some patients withheld information from the spouse concerning their symptoms. Other patients refused to go to hospital when asked by the spouse. In one of these cases an explicit expression of a suspicion of myocardial infarction led to a "wait and see" policy as the spouse wanted to be considerate toward her husband.

The cardiac arrest event

All spouses perceived the situation as serious when the cardiac arrest developed. The theme *"Perceiving the seriousness"* includes perceptions, thoughts, feelings and first actions when it happens. The spouses saw changes in the patient's posture and in some cases changes in the colour of skin. Some heard a wheezing breathing or other strange sounds from the patient. They tried to make contact with the patient by shaking, shouting or slapping the patient's cheeks. When failing to make contact or observing no signs of life in the patient's eyes they again perceived the situation as really serious. A few spouses had checked for a pulse. Other spouses had noted occasional gasping when asked if the patient was breathing. This was, however, not interpreted as a sign of life by any of these spouses. Thoughts regarding the situation were described as the patient already being dead or were dying. A sense of unreality was common and feelings expressed were insecurity, fear and panic, which showed awareness of the seriousness in the situation.

Some spouses lacked ability to intervene and others did not understand the necessity of immediate action and therefore desperately relied on the emergency services ability to rescue the patient. This formed the theme *"To be without the possibility to influence"*. Other obstacles for intervention and

also for carrying out instructions from the ECS were; physical restrictions and feeling of panic. When the signs perceived were interpreted as signs of death or dying some spouses saw no possibility for intervention. In two or three cases the spouses were advised to place the patient in recovery position and in one case the spouse did not comprehend any relevant advise from the ECS.

The theme "*To do what is in ones power"* stretches from wanting to do the best in the situation, to fight for the other person's life in all possible ways and manners. In one case the spouse, being a CPR instructor, started CPR simultaneously with the call for ambulance. The spouses tried to influence the course of the event to the best of their power. Due to variations in the spouses' physical ability and knowledge, interventions differed. The spouses accepted guidance from the ECS and performed CPR. In one case the ambulance arrived before the spouse had the chance to start. Several spouses expressed that they were encouraged to continue with their efforts and felt supported by the operator at the ECS. The guidance from the ECS team therefore seems important.

DISCUSSION

Discussion of methods

Regarding **Papers II** and **III**, the study was conducted during a four months period when all patients from the specified catchments area, who were admitted to the coronary care unit, were considered for participation. Out of the 473 patients who were possible to reach and asked to participate, 72 declined participation. In the perspective of patients treated in the coronary care unit, the participants must be considered to be representative. However, the coronary care unit does not admit every patient with ischemic heart disease at the hospital. Patients treated in non-monitored wards are often older and may have a different pattern of risk factors and another view on CPR and CPR training.

As the study **(Paper I)** was a pilot study, which aimed at testing a model of quality assurance for CPR, the selection consisted of a 'convenient sample' of ten nurses and enrolled nurses working at the coronary care unit during the time the study was conducted. Their participation was voluntary. As a perspective of professionals, we have no reason to believe that this group performed inferior single rescuer CPR than nurses working at other hospital wards or other nurses working at their own unit. The participants were all well trained staff and all except one, were trained in CPR within the past six-months. One person had attended a refresher course 12 months prior this test.

Laypersons, who partake in CPR training courses at the local Heart and Lung Association, were asked to participate in the study (**Paper IV**) without randomisation. All participating in the courses were asked and participation was voluntary. We have no reason to believe that those participating in the study performed inferior CPR than those who declined participation.

Among patients consecutively registered in the Swedish Cardiac Arrest Registry, all spouses who were identified as being present during the cardiac arrest at home were considered for participation (**Paper V**). Due to deficient reporting in the patients' medical records regarding information on the patients' immediate family, there were several spouses that could not be identified. We have no reason to believe that there have been any selections in the reporting of the immediate family.

Regarding the qualitative content analysis, reproducibility could be one way for measuring the reliability of the results. Reproducibility can be measured if the analysis is performed in such a way that it can be followed. The authors did not analyse the text independently. However, the authors followed the whole analysis and discussed codes and emerging themes until consensus was obtained.

Even if the results cannot be generalized from a statistical point of view, as this study is a qualitative study, the results could be transferable to other spouses in similar circumstances. Exceptions cannot be ruled out.

Limitations

In **Papers II** and **III**, we performed no analysis regarding characteristics among those who were unwilling to participate.

In the statistical comparisons between groups, significance could not be estimated due to small numbers in several of the groups. Since this study is not a hypothesis-testing confirmative study, *p-value*s should be treated with caution.

When interviewing there is always a risk of the respondent endeavouring to give the "right" answers and saying what he or she thinks the interviewer wants to hear. The patient's willingness to attend a course could therefore, be over-estimated. On the other hand, the patients' answers concerning their willingness to learn CPR could also have been influenced by the fact that they were interviewed during their stay at the coronary care unit. There were a few patients who commented that they were uncertain about how much they could exert themselves. The willingness to participate in a CPR training course may therefore have been underestimated.

In order to gain knowledge as to whether or not the co-habitants were trained in CPR, we asked the patients. It is possible that some of the co-habitants could have been trained without the patients' knowledge. However, the proportion trained is in line with the estimated proportion of citizens trained in Gothenburg at the time of this study (unpublished data).

Regarding the measurement for quality of CPR performance (**Paper I** and **IV**), we did not use videotape recordings. The author of this thesis made the evaluations of the examination skills, with no co-evaluator present. The coding of the short version of the Brennan *et al*. [110] checklist was easily conducted during the performance. However, videotape recordings of the

sessions would have made a second evaluation according to checklist possible, which would have strengthened the reliability of these judgements.

The measurement of the number of ventilations and chest compressions is based on the time from 'CPR started to CPR stopped' in the Skillmeter programme and measured slightly different in the SkillReporter programme. Therefore the results from the Skillmeter version are not completely comparable with those from the SkillReporting system.

It is not possible to see the actual depth of each chest compression, as the computer and the Skillmeter™ as well as the SkillReporter system present averages and the amount, and the proportion of too deep or too shallow chest compressions. We have no way of knowing if occasional chest compressions were injurious.

Regarding **Paper V**, less than half of the spouses who were invited to participate in the study were willing to be interviewed. Unwillingness to talk about the event and stir up emotions was one reason expressed by some of those who declined participation. We have no way of knowing if their experiences differ from those who were willing to talk about the event. Additionally only Swedish spoken spouses were interviewed. Therefore we have no knowledge how people from other cultures experience a cardiac arrest at home.

The results compared with the experiences of others

Awareness and attitude towards CPR and CPR courses

Studies have revealed a fundamental lack of knowledge about CPR among patients [117-119]. In the present thesis, 64% of the participants knew that CPR is comprised of both assisted ventilation and chest compressions, which is similar to the result in the study by Ågård *et al*. [117]. Among all participants, 40% had received some CPR training (**Paper II**). Among those who were co-habiting 46% had received such training at some time (**III**). Lack of awareness seems to be the major reason for not being trained in CPR. Many were unaware of the existence of CPR courses for the general public and many had never thought about attending a course (**II**). "Never thought about it" was also a common cause for not being trained among family members of patients with heart disease in other studies [73, 78]. This fact clearly demonstrates that medical professionals cannot rely on other sources providing information on CPR courses to this group.

Willingness to undergo CPR

In the present thesis the majority were willing to undergo CPR in case of an emergency (**Paper II**). Older patients and patients with a medical history of myocardial infarction or heart failure were in favour of receiving CPR to a somewhat lesser extent than those without. We do not, however, know on what grounds. The knowledge of CPR was only investigated with regard to the concept, what it means and how CPR is performed, and success rates were not discussed in the present thesis. Studies have shown that most people overestimate the chances of survival [117-122]. Existing information regarding the influence of education on the willingness to undergo CPR is, however, not conclusive [118, 120, 122-124]. Van Mil found that [122] of the older patients who had received information including a standard description of CPR, possible complications following CPR and realistic chances for survival resulted in the fact that 65% did not want CPR. In a study by Hansdottir *et al*. [124], 75% declined CPR after a standard description of CPR and information on realistic survival rates [124]. Ågård *et al*. [117] showed that many patients with heart failure opted for CPR no matter how small their chances for survival were. Ninety percent of the participants were willing to undergo CPR, which is in line with our result. When presented with a variety of survival rates, 67% still opted for CPR when the survival rate was 5% percent or less [117].

Prevalence of training among co-habitants

Family members of persons at high risk for cardiac arrest do not have more training in CPR than other persons despite the fact that they should be a prioritized group for training [73, 80, 125]. The present thesis (**III**) supports these findings as the proportion of co-habitants trained in CPR corresponds with the estimated proportion of CPR-trained citizens in Gothenburg (34%, unpublished data). We also noted that less than half of the spouses who had experienced their husband or wife's cardiac arrest at home were trained in CPR (**V**). Kligel *et al*. [80] investigated the interest for participation in a 1-day CPR course among cardiac arrest survivors and their family members with a mailed questionnaire. In the questionnaire they were also asked if the respondents had previously participated in a CPR course, and if so, when. Members in a control group were asked to fill in the same questionnaire as the target group. In their study 55% of the target group and 52% of the control group had attended a CPR course at least once previously, which was a slightly higher proportion than in the present thesis. However, only two of the respondents in the target group had attended a CPR course within the previous 12 month. Those who had taken part in a course had done this on average 22 years ago [80]. As we know that skills of performance in CPR

deteriorate rapidly with time following education [97, 109], and that ineffective CPR has no influence on survival [87, 88], one can speculate as to whether or not those who were trained a long time ago will manage to perform any effective CPR at all.

The majority of those who were trained in the study by Platz *et al*.[73] had trained due to school or work requirement and not because of concern for a family member, which also was shown in the present thesis. Only a minority in the present thesis had been trained because of their own or a friends heart condition and, also in line with other studies, very few had recent training [73, 80]. This clearly shows that the resuscitation councils' intention to reach this important target group with CPR training has failed. A probable explanation for this is the lack of efforts made. Very few of the patients in the present thesis had received information regarding CPR training from any medical professional person, despite the fact that many should have been included in the target group for CPR training (**II**). In the study made by Platz *et al*. [73], only 2% of the family members of patients considered to be at risk for out-of-hospital cardiac arrest had ever received the suggestion from a medical professional that they should obtain CPR training, whilst 58% stated that they would have been positively influenced by such a recommendation. It has been shown that medical professionals are reluctant to give information or recommend CPR courses to their patients [72].

Possibilities for CPR training

In this thesis the majority of the patients had a positive attitude towards CPR training. Among those who had never attended a CPR course, nearly half and slightly more among those who were co-habitants (58%), were interested in being trained in CPR (**II**, **III**), which is in line with the result from Platz *et al*. [73]. In those cases, when the patients' co-habitant lacked CPR training, a majority wanted him/her to attend a course and many were willing to attend a course together with their co-habitant.

CPR courses seems to primarily attract younger people as those who attend CPR courses have been found to be younger with only a minor part in the age group >50 years [70] or >59 years attending [71]. In the present thesis younger patients were more willing to attend a CPR course than older patients.

Additionally, in the study by Axelsson *et al*. [71] most attend a CPR course because of school or work requirement and 25% because of general interest, while only 1% attended because of their own cardiac disease or friend or relatives cardiac disease, which is in line with our findings. However, Lester

et al. [74] showed that it was possible to attract a group of people with a specific relation to cardiac disease. The authors advertised the planned training sessions in the local press together with a series of articles presenting different individuals who had been instructed in basic life support techniques. In the series of articles they also included a front-page story about a cardiac arrest victim who had collapsed in the city centre and who had been resuscitated by a layperson who was trained in basic life support. In conjunction with this the readers were asked if they would know what to do in a similar situation and were told that they could learn these skills at the offered mass training sessions. The readers of the local press which was used in the study, were 62% non-manual workers and 47% aged 45 years or older. Of those who took the training in the study by Lester *et al*. [74], 35% were 45-64 years of age and 9% were 65 years or more. Females constituted 65% of those trained. In a random sample group of those trained, 67 % were related to someone who had a heart problem, which shows that they succeeded in their attempt to reach the target group.

Obstacles to training

As people with known cardiac disease and their relatives are not trained in CPR to any higher or even to a lesser degree than others, there are obviously some obstacles to training. High age, limitations regarding their own medical condition and the co-habitants physical condition were found to be obstacles to training in the present thesis (**III**). Additionally it seems, as if the previously discussed lack of awareness is an obstacle to training among this group (**II**). Keim *et al*. [126] found that those who indicated physical limitations , 'lack of interest', concern about 'potential legality' and 'health risks' as the reason for not being trained in CPR, were ten times more likely to decline CPR training, compared to those who indicated "don't know why" and "courses not convenient". The authors conclude that a certain significant elderly subgroup may strongly resist or ignore educational interventions.

Old age as an obstacle to training was also found by Swor *et al*. [127]. In their study, those over 80 years of age were significant less likely than those who were younger to be willing to learn CPR. They also perceived themselves unable to perform and were unwilling to perform CPR in case of an emergency in a significantly higher degree than those who were younger.

The reluctance we found against attending a CPR course specifically designed for people with heart conditions and their relatives, was somewhat surprising (**III**). The fear of being connected to the disease or fear of too much discussion about diseases, which was expressed by those patients, clearly points out the difficulty in attracting some patients to such courses.

Hansson Scherman [128] found in one study in persons with asthma, different ways to relate to their own situation when chronically ill. Not wishing to be perceived as sick (normification) was one way to relate to the situation. The persons who had this perception (normificative) on the situation, strived to be viewed as healthy and were aware of the risk to be stigmatised. By choosing to be among healthy people, their identity as a healthy person could be strengthened. It is obvious that with this outlook on life, these persons will be resistant to specifically designed courses for patients and relatives and they will not seek participation in patient associations.

What factors may influence patients and co-habitants in participating in CPR training?

One factor may be that medical professionals inform patients and their co-habitants about CPR courses and motivate them to attend. A requirement for this could be that the medical professionals themselves believe in the possibility of victims living a life that is good and meaningful after they have been saved. If the medical professional is of the opinion that those who survive a cardiac arrest do not live a dignified life, it is unrealistic to believe that they will inform anyone about CPR courses. It is therefore of the utmost importance to study the neurological outcome after cardiac arrests and not only survival, which is also emphasised in the update of Utstein templates [40].

One additional factor which may influence patients and their co-habitants to attend CPR courses is if the courses are easy available in the vicinity of the home (**II**).

Quality of CPR performance

Immediately after training the laypersons in this thesis performed a relatively high proportion of their chest compressions correctly (**IV**). The low amount of compressions over time was an effect of prevailing guidelines and could have been only slightly higher. In terms of skill acquisition, the result was somewhat better compared to other studies [91, 94]. This skill, however, deteriorated significantly during time for the three months test.

In the present thesis the pulse control was performed as prescribed according to Brennan *et al.* [110] by many of the participants. In a realistic situation this does not guarantee a correct diagnosis. In a study of the accuracy and delay of the diagnostic assessment of pulse by first responders at various stages of CPR training, Eberle *et al*. [22] found that only a few managed to decide whether or not a pulse was present within 10 seconds. The median delay until

decision was 24 seconds and if no pulse was present, the time was extended to 32 seconds. Even if the level of training had an effect on shortening the delay it still took 20 seconds or more for half of the two most experienced groups (paramedics after 1 year in training or certified after finishing of the 2-year training) to decide whether or not the patient had a pulse. The check for pulse therefore seems difficult. However, few of the spouses in the present thesis tried to check the pulse. Nevertheless they all understood the seriousness of the situation and called the emergency number. There was no doubt that the situation was serious when the spouses were unable to make contact with the patient. Even in those cases when the spouse noted a wheezing breathing there was no doubt about the seriousness.

In the present thesis half of the participating nurses (**I**) and a minor part of the laypersons (**IV**, three months after training) opened the airway prior to attempting a check for breathing. In a study in Helsinki and Budapest, nurses on medical wards and an emergency ward together with nursing students were tested with regard to their CPR skills [90]. Nyman *et al*. [90] found that 67% opened the airway by tilting the head or lifting the chin. This, however, was often done after those participants attempted to check for breathing and is also in line with our experience. As we followed the Brennan *et al*.[110] checklist in the present thesis, only those who opened the airway prior to check for breathing were judged to have managed the check for breathing successfully. According to the checklist, the rescuer should first open the airway, then place their face near the manikins face and look at the chest for at least three seconds [110]. As the evaluations were performed with different methods the results cannot be compared. However, it is clear that the check for breathing is a major point of concern not only for the groups in the present thesis. In a study of lay person's skill-performance immediately after a four hour CPR course, Brennan *et al*. [91] found that 50% of the participants failed to perform the check for breathing correctly which is in line with the result in this thesis. The opening of airways therefore seems to be a difficult task for laypersons to learn and remember. Furthermore it seems difficult during telephone CPR instruction to guide others, to make this as quickly as it needs to be done. One of the spouses in the present thesis was occupied with opening of airways until the arrival of ambulance and did not perform any chest compressions (**V**).

Regarding ventilation, the proportion of correctly performed ventilations was low among the nurses (**I**) as well as among the laypersons both immediately after training and three months later (**IV**). Most ventilations performed by the nurses (**I**), were made with a flow rate which was 'too fast' and a great proportion were made with a volume which was 'too much', which increases

the risk for gastric inflations. The laypersons, however, often under-ventilated the manikin (IV).

The result from the test of the nurses is in contrast to those in a study made by others [91, 129]. The medical students in the study by Heidenreich *et al*. [129] were unable to perform rescue breathings with sufficient volumes and made insufficient number of inflations. Immediately after training they managed to deliver 5±2 ventilations per minute but six month later only 3±1. On average the nurses in the present thesis made nearly twice as many (6±0.9 ventilations per minute). However, among the participating laypersons in our study the result corresponds with those performed by the medical students in the study by Heidenreich *et al*. [129].

In line with the results of the laypersons in the present thesis under-inflation was the most common error in the study by Brennan *et al*. [91]. In their study where participants were tested immediately after public CPR courses. The mean proportion of ventilations correctly performed was low (27%, median 10%) and in line with the result of the 17% (median 12%) in present thesis. However, concerning chest compressions participants in the present thesis performed far better immediately after training than those in the Brennan *et al.* [91] study where a mean of 17% (median of 2%) of the chest compressions were correctly performed. The relatively high proportion of chest compressions correctly performed by the laypersons in the present study immediately after training (mean 60%, median 67%) was, however, significantly reduced in the three months test and became similar to those by Brennan *et al*.[91].

The problem with chest compressions performed with a totally incorrect hand position, with compressions on the abdomen rather than on the chest, as we noted among a few cases in the test three months after training (IV), was also noted by Brennan *et al.* [91].

Regarding chest compression rate, participants in the present thesis performed rates that were somewhat slower compared to 105±14 performed by medical students six month after training in the study made by Heindenreich *et al*.[129], or 105±23 performed by lay persons in the study by Assar *et al*. [96] immediately after training.

There are few studies which report the actual number of chest compressions delivered per minute. In the study made by Heidenreich *et al*. [129], the actual number of chest compressions per minute was 49±14 six month after training, which was somewhat more than performed by the participants in the

present thesis (**Paper I**; mean 41±6, **Paper IV**; 36±10). The lay persons in the study by Assar *et al*. [96] managed to perform 39±11 compressions per minute immediately after training. However, nearly half of the participants failed to achieve the recommended compression depth of 38-51 mm [96]. Heidenreich *et al*. [129] do not report any results showing how the delivered chest compressions were performed by the medical students. Chest compression 'too shallow' seems to be a major problem in many studies [91, 92, 96, 98] as well as among the laypersons in the present thesis. Insufficient depth was the most common error in the performance of chest compressions immediately after training. Wik *et al.* [130] showed that paramedics and nurse anaesthetics performed in mean 59% of their chest compressions with a depth which was 'too shallow' during the first five minutes, and 62% during the entire time of the resuscitation episode in out-of-hospital cardiac arrest victims. The nurses in the present thesis performed deep enough chest compressions and only a few were 'too shallow' (<38 mm) during approximately three minutes CPR on a manikin. Even if the results from the study by Wik *et al*. [130] are not comparable to those in the present study, as their study was conducted in real situations while conducting advanced cardiac life support, it is worth noting that more than half of the time was time without any chest compressions. A compression rate of 120±20 resulted in 60±25 chest compressions per minute in spite of the fact that the patients were intubated and therefore could be ventilated during considerably shorter pauses between the chest compressions.

What is optimal CPR?

Even if there is no doubt that CPR is important, as the lowest survival rates occur when CPR is not attempted, there has been uncertainty regarding how good CPR should be in order to save lives [28]. Before the international guidelines were changed in 2005 [25] there were a number of studies showing the need for a change [31, 33, 129, 131, 132]. However, the question of what an optimal CPR really is, still remains to be answered. As studies with measurements on various aspects of CPR quality are mainly conducted on animals, one might argue whether or not the results are transferable to humans. New technology has been developed that may help to solve this question [133].

Is there any optimal chest compression rate?

According to current guidelines compression rate should be 100/min. The rationale for this recommendation was that the rate of 100 per minute had been shown to be effective in practice [28]. Even if the compression rate is high, the amount of chest compressions over time is limited by the two rescue breathings that should be performed, previously after every set of 15 chest compressions and now since the implementation of guidelines 2005 [25], after every set of 30 chest compressions. As the studies in the present thesis were conducted prior to the implementation of these newly introduced guidelines, the 2:15 ratio was used in both studies. The nurses performed chest compression with a mean rate of 95 ±18. In spite of this fact, the actual number of compressions during one minute varied from 32 to 51. In the 1998 European Resuscitation Council Guidelines [28] there was still a belief that a chest compression rate of 100/min would result in 60 compressions per minute, as it was calculated that two rescue breathings should take six seconds. It was later shown that lay volunteers after CPR training made interruptions for ventilations as long as 16 seconds each time (instead of 6 seconds), which resulted in 39 compressions per minute instead of the calculated 60 per minute [96]. When performing CPR on pigs with the same long interruptions for two breaths this resulted in a 13% survival rate with normal neurological functioning, compared to 80% if only chest compressions were given [33]. Yu *et al.* [134] showed that at least 80 chest compressions per minute were needed for a successful resuscitation in the case of a prolonged cardiac arrest on pigs. With previous guidelines it was impossible to achieve 80 compressions per minute even with a rate as high as 120 per minute. Theoretically it should be possible to achieve 80 chest compressions per minute using a chest compression rate at 120 per minute when performing 30:2 compression: ventilation ratio, if only 10 seconds is used for the two inflations. However, Heidenreich *et al.* [129] showed that young medical students made pauses in chest compressions for rescue breaths that were 14±7 seconds immediately after training. With the ratio 15:2 they performed 43±7 chest compressions per minute with a compression rate of 121±14. The only way to increase the time for circulatory support and the number of chest compressions over time is therefore to decrease the number of interruptions. The change in guidelines 2005 to increase the ratio to 30:2 is a step in the right direction. However a goal of 80 per minute will probably not be reached. Additionally, for most people compression rates as high as 120 per minute is difficult to achieve, whereas 100 per minute may be easier. It is thus important to keep the pauses for ventilation as short as possible and to compress the chest with a rate no slower than 100/min. For older laypersons this rate may, however, be unrealistic to achieve as indicated in the present thesis (**IV**).

Optimal depth of chest compressions

It has previously been shown on animals that cardiac output, coronary perfusion and arterial blood pressure increased with increasing compression force [135], at least up to a certain level [136, 137]. Halperin *et al*. [138] showed that the compression force applied had to reach a certain level before any myocardial or cerebral perfusion pressure was obtained. Measurements in human subjects during resuscitation procedures are rare. However, Paradis *et al*. [139] conducted a study, presented in 1990, where this was done on patients admitted to a hospital with cardiac arrest prior to admission. They showed that a minimum of myocardial blood flow is necessary in order to obtain return of spontaneous circulation. They also found that the maximum coronary perfusion pressure was a strong predictor for return of spontaneous circulation. The positive predictive value increased with the coronary perfusion pressure and was 0.79 at 25 mm Hg. No one with a coronary perfusion pressure below 15mm Hg received return of spontaneous circulation. Therefore, the optimal compression depth is a depth which leads to a coronary perfusion pressure as high as possible, and not lower than 15mm Hg. The compression depths were not measured during the study by Paradis *et al.* [139]. Recently, the force used during manual chest compressions has been measured and compared to obtained depths [140]. It was found that, in the majority of cases, a compression depth of 38 mm was obtained with a force of less than 50 kg. It was also found that the paramedics adjusted the force to the stiffness of patients' chest to some extent. Softer chests were compressed deeper than stiffer chests even though stiffer chests were compressed more forcefully [140]. In a study made by Steen and co-workers, manual chest compressions were compared with compressions made by a mechanical device performing active compressions and decompressions, LUCAS (Lund University Cardiac Assistance System), regarding haemodynamics and survival in pigs [141]. With manual chest compressions, the mean calculated coronary perfusion pressure (the thoracic aortic diastolic pressure – diastolic pressure in right atrium) was approximately 10mm Hg compared to 17mm Hg with LUCAS. For all pigs that received return of spontaneous circulation, the mean coronary perfusion pressure was 15±5 mm Hg. No pig that received manual chest compressions survived. In the study by Steen *et al*. [141] LUCAS compressed the chest 25% of the chests height. In most studies the compression depth is not presented. Bellamy *et al*. [135] found a far better coronary flow when they increased the compression depth from 2 inches (5cm) to 2,5 inches (6,4cm). However, Wik *et al.* [142] surprisingly found a reduction in the myocardial blood flow despite a higher coronary perfusion pressure when the compression depth was increased.

Thus the optimal depth of chest compressions is difficult to decide. It seems, however, clear that too shallow chest compressions (<4 cm) are not likely to produce coronary perfusion pressures high enough to obtain return of spontaneous circulation.

The participating nurses in the present thesis (**I**) managed to achieve a compression depth well above minimum requirement (≥4 cm). Only a small proportion of the chest compressions were 'too shallow' while 40% were 'too deep' (>5 cm). However, among the laypersons a higher proportion of chest compressions 'too shallow' were seen. Few made any compression 'too deep' in this group (**IV**).

Optimal volume of rescue breathings

During resuscitation ventilation is performed in order to add oxygen to and reduce carbon dioxide from, the victim's blood. The level of carbon dioxide is related to the pH, the higher level of carbon dioxide the lower pH. Both the volume and frequency of ventilation influence the level of carbon dioxide and oxygen.

Guidelines regarding inflation volume have varied over the years. When the first CPR training programme was introduced, 800-1200 ml/breath were recommended. When the risk for gastric inflations by too large tidal volumes and too high inflation rates were noticed, the guidelines were changed and reduced volume was recommended by the ERC in 1998. The choice of magnitude of the reduction was based on seemingly vague evidence. As a tidal volume of 400-600 ml was perceived as adequate for resuscitation and sufficient to cause the chest to rise [143], the ERC chose this volume as a recommendation. The benefit with this new volume was also pedagogic as it was consistent with the accepted teaching that the tidal volume should be that which causes the chest to rise. In Sweden this new inflation volume was not adopted. In 2000 when the ERC [24] increased the recommended ventilation volume to 700-1000 ml/breath (10 ml/kg) without supplementary oxygen, this was then implemented into the Swedish programme. While comparing blood gas analysis from patients receiving ventilations with either tidal volume of 500 ml or 1000 ml, Langhelle *et al*. [144] found significantly lower PCO_2 values in patients ventilated with 1000 ml per breath. The pH tended to be lower at five minutes and became significantly lower in the 500 ml group after 10-15 minutes. As all patients were ventilated with 100% oxygen, the PO_2 was high in both groups [144]. Recently Dorph *et al*. [145] showed that a tidal volume of 700 ml (and respiratory frequency 12/minute) resulted in normocapnia when this volume corresponded to 10 ml/kg. However, this result was achieved under optimal circumstances with very

short interruptions for the rescue breathings and may therefore not be transferable to single rescuer CPR performed by lay persons. Additionally, it is both practically and theoretically impossible to perform 12 mouth-to-mouth ventilations per minute during single rescuer CPR, which has also been shown in the present thesis and by others [129]. Thus, the optimal volume of rescue breathing is difficult to resolve.

Optimal frequency of rescue breathing

The role of ventilation during CPR due to primary cardiac arrests is not clear and is avidly discussed. While some studies have shown the importance of ventilation during prolonged resuscitation [146], it has also been argued that it might not be needed at all during the first minutes of the resuscitation procedure [147, 148]. It has further been discussed whether ventilation (or hyperventilation) may also be deleterious during resuscitation. If the patient is unintubated, rescue breathings reduce the number of chest compressions over time. The intrathoracic pressure increases by the ventilations, which has been shown in laboratory studies to affect the survival negatively, probably due to a reduced coronary perfusion pressure [149, 150]. Pitt and Kellerman [151] argue that the risk for respiratory alkalosis increases with hyper-ventilation, which reduces oxygen delivery to the tissue. Furthermore hyper-ventilation causes vasoconstriction, which may reduce the cerebral perfusion. Survival rates in a study by Aufderheide *et al*. [150] were six of seven (86%) when pigs were ventilated with 12 breaths per minute. When the pigs were ventilated with 30 breaths per minute, one of seven survived. As long as the bystander combines the rescue breathings with chest compressions there is, however, no risk for hyperventilation during single bystander CPR.

During the pauses for rescue breathing the coronary perfusion pressure decreases and it takes time to build up this pressure again. Therefore the coronary perfusion pressure differed markedly between the first and the last two chest compressions after the pauses for ventilation in each compression cycle [148, 152]. This was the reason why the chest ventilation: compression ratio was changed for two-rescuer CPR in the guidelines 2000, from 1:5 to 2:15. Berg *et al*. [152] showed that even if the oxygen saturation as well as the pH was higher and the PCO_2 lower among the group of pigs who received CPR with the ventilation: compression ratio of 2:15 compared to one group who received chest compressions only, with no rescue breathings at all during the period of 12 minute cardiac arrest, there were no significant differences in survival or neurological outcome between the two groups. The haemodynamic measurements showed that blood flow through the left ventricular myocardium during “chest compressions only”, was nearly the same as pre arrest whilst it was approximately 50% of pre arrest flow during

2:15 ventilation: compression CPR. However, this result was obtained during perfectly performed CPR with only four-second pauses for the ventilations on pigs with no coronary artery disease. In reality the conditions are not as favourable as this.

Steen *et al*. [31] have shown how the haemodynamics are influenced by interruptions of chest compressions. After the initiation of ventricular fibrillation it takes 15 seconds for a normal coronary perfusion pressure of 60mm Hg to decrease to 15 mmHg. If the initiation of CPR is delayed, the coronary perfusion pressure may even become negative due to pooling of blood in the venous circulation causing a distended right heart chamber**.** In those cases it took one minute with perfectly performed chest compressions with a LUCAS to bring the coronary perfusion pressure back to zero, and further 30 seconds to reach adequate levels. When the heart is distended it can't self-contract even if the ECG rhythm changes from ventricular fibrillation to a regular rhythm after defibrillation. [31]. It is therefore of outmost importance to minimize the interruptions of chest compressions.

Sanders *et al.* [153] compared four different compression-ventilation ratios in a study with 40 pigs and found the best neurological outcome in the group who received chest compressions only during the first four minutes, followed by a ventilation: compression ratio of 2:100 during the following eight minutes of cardiac arrest. Thus, it seems obvious that in order to improve haemodynamics during resuscitation and thereby the outcome, the hands-on time with chest compressions has to be increased and the frequency of rescue breathing reduced. In line with these results the ventilation to compression ratio was changed to two after every set of 30 chest compressions, in the European Guidelines 2005 [25]. The question is if this reduction in the number of ventilations will be enough? Could a ventilation frequency of approximately two breaths per minute be the optimal even if this means lower levels of PaO_2 and higher levels of PCO_2 during resuscitation? In the present thesis the participating nurses performed a mean of 5±2 ventilations/minute (**I**) and the laypersons (**IV**) managed to perform 3±3 ventilations/minute three months after training with a ventilation: compression ratio of 2:15 as prescribed in the former guidelines [28, 113].

Why did the professionals in our study not follow given guidelines?

Even if the results deviated from guidelines, there were some deviations, which could be for the better. Half of the participants (**I**) started with chest compressions immediately after pulse control and did not perform the initial two inflations, as prescribed in the former guidelines but was changed in

international guidelines 2005 [25]. One can speculate as to whether or not this could be explained by their experiences of having witnessed monitored primary cardiac arrests at their workplace. In those cases where the victim has been breathing until the cardiac arrest occurs, it is more reasonable to establish circulation as the primary target. Attentions were drawn to this fact, which lead to the change in the guidelines 2005 to start with the chest compressions instead of starting with ventilations.

The depth of the chest compressions made by the nurses in the present thesis, was often 'too deep' (>5cm) while only a few were 'too shallow' (<4cm). As too shallow compressions are unlikely to cause any circulation at all, 'too deep' compressions could be better [135, 138] at least up to a certain level (where this level is we do not know) [136, 137].

The fact that no one managed to perform eight breaths per minute, which were presumed in the ERC guidelines in 1998 [154], and was implicit in the guidelines in 2000[155], shows the difficulty in following these previous guidelines. In the ERC Guidelines 2000 any target amount per minute of ventilations during 2:15 CPR was not mentioned but as it was calculated that 64 compressions should be obtained, this meant 8 breathes per minute. The truth is that it was and still is, impossible to perform as many as eight per minute as a single rescuer with previous guidelines unless the pauses for the two rescue breathings are as short as six seconds. Furthermore, even with pauses of 10 seconds for rescue breathings, it was practically and theoretically impossible to perform for more than approximately 45 chest compressions per minute with the former ratio 2:15.

The flow rate performed by the nurses in present thesis was often 'too fast' (>600 ml/second) and inflations volumes 'too large' (>1200 ml) which could increase the risk for regurgitation in a real situation, as we know that the risk of causing gastric inflation increases with inflations which are 'too large', or 'too fast' [28]. However, when striving to make the best possible situation for the patient, it is easy to hurry and to blow more than what is needed. It may be so that only a machine, programmed for the purpose, could possibly follow the guidelines completely with no errors.

Following guidelines: how important is it?

Guidelines for resuscitation are developed after a critical review of existing evidence of effective procedures handling cardiac arrest victims. However, they are also developed in order to be easy to teach and easy to learn and remember. Both the medical and the pedagogic perspectives have to be taken in consideration. Standardisation and simplification is an important goal in

the developing process. It seems, therefore, obvious why guidelines regarding basic life support do not make a difference between different circumstances in relation to the cardiac arrest, e.g. if cardiac arrests are witnessed or not. In a witnessed cardiac arrest, it has to be considered to be more appropriate to start with chest compressions instead of starting with two inflations as prescribed in the former guidelines.

Following the guidelines, or at least trying to follow the guidelines, is important for several reasons. If we choose not to follow the guidelines we have to know why, be sure we know better and clarify the reason. If departure from guidelines is frequent there is also a risk that results from studies will be influenced which may in turn lead to erroneous conclusions. Difficulties in making comparisons between various regions, within countries and between countries, in terms of outcomes after cardiac arrests, will arise.

Who shall perform CPR in the future?

The possibilities of rescuing those who suffer from cardiac arrests depend on the fact that as many people as possible have the necessary CPR skills. Even if mechanical devises *e.g*. LUCAS perform CPR better than people do, the need for CPR performed by hand has to be applied whilst awaiting the device to arrive to the patient's side. Therefore, even in the future when all Swedish children, who hopefully have learned CPR during compulsory school, have become adults, CPR training for specific groups will be needed. As CPR skills have to be practiced and repeatedly trained in order to be maintained [97]**,** the need for training sessions still will remain.

Will co-habitants use their skills in case of an emergency?

It has been shown by others that there is no guarantee that a family member starts CPR in case of an emergency even if they are trained in CPR [52, 66]. Waalewijn *et al*. [66] found that even if the family member witnessed the cardiac arrest they seldom started CPR. In the study by Swor *et al*. [52] only 30% of the bystanders who were trained in CPR performed CPR when the cardiac arrest occurred at home. Even so when Swor *et al.* [127] investigated the attitudes toward CPR training among older people, they found that a history of cardiac disease in a family member was positively associated with willingness to perform CPR. The time elapsed since last training may have an effect on as to whether or not a bystander starts CPR. In an earlier study Jackson and Swor [46] found that the majority of bystanders who performed CPR had trained CPR within the last five years. However, when support from the ECS is given, it seems as CPR training leads to some kind of preparedness to perform CPR. The spouses, in the present thesis, who had trained CPR at some point of time, accepted the guidance from the ECS when

this was offered and tried their best to perform CPR (**V**). If the co-habitants are trained and if they are offered CPR guidance they may be more likely to use their skills. Additionally it has been shown that many laypersons wish to receive CPR instructions from the ECS [71].

The ECS provided guidance for start of CPR for many of the spouses in this study. Several spouses expressed that they felt supported and that they were encouraged to continue with their efforts. In those cases where the spouses were advised to place the patient in recovery position, the reason could have been that the situation was not clearly clarified. To witness when a near and dear suffer from cardiac arrest is a dramatic and upsetting situation. One study showed that family and friends often were so upset that they were unable to tell what was wrong with the patient [156]. This places a huge demand on the ECS dispatcher to calm the caller and to get the relevant information as quickly as possible.

Will co-habitants call for an ambulance earlier?

In ERC guidelines 2005 [157], early recognition of critical illness and/or angina was emphasized in order to prevent cardiac arrest. This was also added to the first link in the chain of survival.

When asked to tell what happened, all spouses started narrating about the time before it happened. In all cases the cardiac arrest was completely unexpected (**V**). It became evident that often there were no signs before the cardiac arrest. According to previous studies this is often the case. The cardiac arrest event is the first sign of an underlying coronary artery disease in a great proportion of patients without any symptoms prior to the event [158]. In those cases the spouse had no chance to call for an ambulance before the cardiac arrest was a fact. In some cases the spouse recalled that there had been signs before the event. Signs that were either difficult to interpret or that were interpreted as occurring due to an earlier illness. The signs and symptoms preceding the event were often unspecific, showing the difficulty to act proactive.

There seems, however, to be a lack of knowledge concerning the variety of symptoms that may occur in connection with myocardial infarction. As shown by others, people expect central chest pain in the event of a myocardial infarction but sometimes experience other symptoms. When their expectations are not met seeking care is delayed [159, 160]. According to the descriptions of the cardiac arrest event made by the spouses in this thesis, no one of the patients experienced central chest pain prior to the cardiac arrest. It has been shown that approximately one third of patients with diagnosed

myocardial infarction did not experience any chest pain [160, 161]. The true proportion of patients that experience chest pain is, however, not known as only those who reaches the hospital can be asked. The most common symptom described by the patients in the study by Horne *et al*.[160] was sweats or feeling "feverish".

Those spouses, who described, that the patient had pain a few seconds before the cardiac arrest, had no chance to intervene proactively. One of these was the spouse whose husband had a myocardial infarction one week earlier. She described that symptoms and signs were all different from those when the husband suffered from his myocardial infarction. The spouse had difficulties in interpreting the signs and did not consider the possibility of a new infarction. It has been shown that patients without chest pain wait longer to seek for care [160, 161]. Likewise, there are indications that patients with previous myocardial infarction are no better prepared in seeking care when experiencing another infarction. In a qualitative study of the decision-making processes among patients experiencing a second myocardial infarction Pattenden *et al.* [162] found that symptoms often were different from expected and that the patients waited until a symptom in common with the previous infarction occurred before they sought care. Knowing the diverseness of symptoms that may arise is one prerequisite for being able to act proactively. Beside knowledge, coping-strategies also influence the patients' way to handle a situation [163]. Patients having a problem-focused or active-cognitive approach, seek for care earlier than those who had an emotion-focused strategy [162, 163]. The role of defence mechanisms e.g. denial, have also been shown to affect the decision making process [164, 165]. We found signs of denial in a few cases. According to Alonzo *et al.* [165], the risk for unaware defence mechanisms increases the more threatening the situation is perceived to be. Walch *et al*. [163] on the other hand showed that the patients perceptions of how serious the consequences for a myocardial infarction are, influenced the decision to seek care.

CONCLUSIONS

- Most of the cardiac care patients had a positive attitude towards CPR. Only a few did not want CPR in the event of an emergency. Approximately two-thirds of the patients were educated or wished to be educated in CPR (**II**).

- A great proportion of the patients' co-habitants were not trained in CPR.
    - Two-thirds of those patients who were co-habiting were unsure or did not believe their co-habitant had CPR training and more than half of these wanted their co-habitant to attend a course (**III**).

- There was a great interest in participating in a CPR course.
    - Seventy-two percent of the participants previously trained, or willing to be trained in CPR, were interested in participating in a CPR course together with their family member or co-habitant (**III**).

- Younger patients were more willing to participate in CPR training than those who were older. The main obstacle to CPR training was the own medical condition. The major reason for the informants' objection regarding co-habitant's participation was doubts concerning their partner's physical ability or interest in participation (**III**).

- The combination of a simple checklist and a computer program facilitates data gathering for the instructor and enables quality controls as a routine procedure. Moreover, quality controls at different levels, both individual and collective, of students' skill-retention are possible, as well as comparisons of various training methods at national and international levels (**I**).

- The results expose several points of concern regarding CPR training and skill-retention, such as the difficulties in making the pauses for ventilations short enough. The amount of time for chest compressions, therefore, becomes insufficient (**I, IV**).

- The level of skill retention three months after training according to International and Swedish guidelines 2000 was far below acceptable level. Our study indicates the need for a dramatic simplification of the education message in order to improve skill retention (**IV**).

- Spouses' descriptions of their experiences in connection to the cardiac arrest at home included completely lack of early warning signs or denial of signs. Signs present were difficult to interpret or could be misinterpreted due to earlier illness. When the cardiac arrest occurred all perceived the seriousness. While some had no possibility to influence the event others did everything in their power trying to influence. The ECS played an important supportive role (**V**).

Implications

Ways for enhancing bystander intervention

Information on the various symptoms that could precede a myocardial infarction, and the necessity of seeking care in the event of these symptoms, is important for the general public. For patients, after experience a myocardial infarction or other signs of ischemic heart disease, this information is even more important. However, when doing so one has to take into consideration not to cause too much threat. Focusing on the positive side of seeking care i.e. the possibility to reduce the infarction and thereby reduce possible side effects, could be one way to reduce threat. However, there will always be the risk for development of cardiac arrest with no possibility to act earlier as shown in this thesis. Therefore the knowledge of and skills in CPR have to be spread to as many people in the society as possible. Special attendance has to be given to cardiac care patients and their family members, to give them the opportunity to train these skills. Spouses, who had previous CPR training among the interviewed, accepted guidance. They all tried to do what was in their power to influence the course of the event (**V**). However, the assistance by the ECS to provide guidance seemed important. Without the support from ECS, few of the patients would have received CPR.

The most common reason for lack of training in CPR among the cardiac care patients was that they were unaware of the existence of such courses or that they never had thought about it (**II**). Therefore, information about CPR courses is important. Medical professionals should provide patients and their co-habitants with information and motivate them to acquire and maintain CPR skills. Multiple strategies are needed in order to meet the patients' individual needs (**III**). Offering CPR courses in the rehabilitation programmes following coronary events would meet the need of providing a safe

environment for the course. For those who prefer to attend a course with healthy people or in the vicinity of their home, the medical professionals could help the patient to find a suitable course elsewhere. The primary health care centres should provide CPR courses both for their patients and people living in the area.

Ways of enhancing quality of CPR performance

The present thesis has shown that the given guidelines have not been followed, which may affect the possibility for correct diagnosis and the treatment of cardiac arrest patients (**I, IV**). One reason for this failure is that the guidelines were impossible to follow. One requirement for new guidelines to be observed and generally accepted should be that they are possible to follow. The present thesis also shows that previous guidelines lead to an insufficient amount of chest compressions over time. Combining chest compressions with rescue breathings during single rescuer CPR is a difficult task. The opening of airways and performing of ventilations seems to be too difficult for many laypersons. It is therefore urgent, especially for this group , to reduce the number of skills taught to those absolutely necessary for live saving. This could make it easier to perform CPR when the cardiac arrest has happened.

Future research

Whilst working with the present thesis and reading the literature, more questions have been revealed that require further investigation.

- Why do nurses and physicians not recommend CPR courses to cardiac care patients?

- How will cardiac care patients and their family members receive the newly introduced Swedish CPR educational programme?

- Is it possible to find ways to support those who do not see any possibility to influence the course of the event, to accept guidance from ECS?

Summary

Introduction: Out-of-hospital-cardiac arrest is a major factor of mortality in western countries. In the event of a cardiac arrest, the immediate start of cardiopulmonary resuscitation (CPR) can save the life. The majority of cardiac arrests occur in the patients' home, it is therefore vital that family members have knowledge and skills for appropriate action. Studies have shown that the quality of performed CPR is crucial for the outcome. It has been shown that even if a family member witnesses the CA they often omit to start CPR.

Aim: The overall aim with this thesis was to describe various aspects of CPR training in order to find approaches for enhancing bystander interventions.

Methods: A questionnaire was used for studying cardiac care patients' attitude towards CPR and interest in CPR training. Patients consecutively admitted to a cardiac care unit were interviewed (n=401) (II). Among those who were co-habiting (n=268), possibilities for and obstacles in relation to CPR training together with the partner were investigated (III). An instrument for measuring quality of CPR performance was tested in a pilot study using a suitable selection of cardiac care nurses (I, n=10). Quality of performance was studied among laypersons after CPR training and three months later (IV, n=32). For describing spouses' experiences during the cardiac arrest at home fifteen spouses were interviewed. The interviews were tape recorded and transcribed verbatim. Qualitative content analysis applied (V).

Results: Most of the cardiac care patients had a positive attitude towards CPR and many had trained or wished to undergo training in CPR (II). Two-thirds of patients who were co-habiting were unsure or doubted that their co-habitant had received CPR training, with more than half wanting their co-habitant to attend a course. Younger patients were more willing to participate in CPR training than those who were older. Major obstacles for CPR training were their own medical condition, and doubts concerning co-habitants physical ability or interest in participation (III). Measurements of the quality of CPR performance revealed several points of concern regarding CPR training and skill-retention; the difficulties in making the pauses for ventilations short enough, enabling enough time for chest compressions, leading to low number of chest compressions per minute; and poor performance regarding ventilations (I, IV). Immediately after training the laypersons performed relatively high proportions of chest compressions correctly, which, however, after three months decreased significantly. 'Too shallow' chest compressions were common (IV) whilst the cardiac care nurses often made chest compressions 'too deep' (I). Spouses' experience of

cardiac arrest at home included two time domains and seven themes. Prior to the cardiac arrest the descriptions of their experiences included a complete lack of early warning signs or denial of signs. Signs present were difficult to interpret or could be misinterpreted due to earlier illness. When the cardiac arrest occurred all quickly perceived the seriousness of the situation. While some lacked the possibility to influence the event others did everything in their power trying to influence the outcome. The ECS played an important supportive role by guiding spouses in performing CPR (V).

Conclusion: CPR training for cardiac care patients and co-habitants is important and feasible. The outcome of training has to be enhanced. Simplification of the message and reduction in number of skills taught seems urgent. Symptoms and signs regarding myocardial infarction have to be communicated more clearly.

ACKNOWLEDGEMENTS

A number of persons have contributed to this thesis in different ways. First of all, informants and participants involved in the studies, to whom I am deeply indebted and grateful.

To others, without whom I would have barely managed to fulfil this task and to whom I would like express my sincere gratitude are:

Johan Herlitz, Professor in Cardiology and my Super Supervisor, who supported me by believing in my capacity, and encouraged me to continue: Being enthusiastic, extremely knowledgeable and interested in the subject, and being the true pedagogue, you have inspired me whenever I had doubts.

Åsa Axelsson, lecturer at the Institute of Health and Care Sciences, my supervisor and very good friend, who skilfully has guided me in both the quantitative and qualitative sciences and in the process of writing: Your straight forward manner have forced me to try even harder.

Stig Holmberg and Lars Ekström, visionaries and "the fathers of CPR" in Sweden: You opened my eyes to all the mysteries in this "little" subject when I worked as a Principal instructor in Advanced CPR in Marstrand.

Ella Danielson, Professor at the Institute of Health and Care Sciences, my tutor in the qualitative content analysis course and co-writer: Your wise comments and your supervision have been invaluable.

Jonny Lindqvist, computer-programmer and expert, with the "power" to handle the registers and the skills in statistics: I appreciate your patient help with figures and p-values.

Thomas Karlsson, statistician, who guided me in the choice of statistical methods: I was so glad to have been able to pop in and ask questions.

Geir Inge Tellnäs, Laerdal, Norway: Thank you for answering all my e-mail questions regarding the computer programmes.

Leif Havås and all the other CPR instructors who voluntarily, without any financially compensation, educate laypersons in CPR and are doing a great

job: Thank you for not only accepting my being there, but also inviting me to your CPR training courses.

Mona From Attebring, Maria Bäck, Åsa Cider, Bente Grüner Sveälv, Meta Scharin Täng, Cecilia Litborn, Annika Odell, Elisabeth Perers, Anita Persson, my dear colleagues in the "Doctoral group" as well as "Support group" who patiently have read most parts of my thesis and supported me with constructive critics: I am glad you were on hand!

My care-unit-supervisor Ann-Sofi Strömvall Larsson and all my colleagues at the Cardiology Research unit. I would especially like to thank Lillemor Fasnacht Stensdotter, Margareta Sjölin and Lisbeth Winberg, the true caring nurses at my working place: You have made my work more fun and easy.

Birgitta Franzén secretary and my PowerPoint expert: I also appreciate I can ask you on all practical matters.

Maureen Anwyn Jehler, secretary emeritus and my British English expert, who struggled together with me to get this thesis in shape for print: I will never forget what you have done for me!

Solveig Aune and Gunnel Kanbrant at the CPR unit at Sahlgrenska, who have helped me in various ways and matters during the years: Thank you for being the helpful persons you really are.

Being surrounded by nice and friendly experts has made this long journey a pleasure!

Last, but certainly not least, I want to thank my family; Kjell, Anders and Claes for being the essence of my life.

Ing-Marie Jonsson, my sister, who showed me the way through life and to this exam.

Mina föräldrar Inga och Karl-Gustav Jonsson: Tack för att ni alltid har uppmuntrat och stöttat mig.

The studies have been supported by grants from:

The Laerdal foundation for Acute Medicine,
The Swedish Heart and Lung Foundation,
The Health and Medical Care, Executive Board of the Region Västra Götaland,
Lars Mogensen Foundation.

REFERENCES

1. Sans S, Kesteloot H, Kromhout D. The burden of cardio-vascular diseases mortality in Europe. Task Force of the European Society of Cardiology on Cardiovascular Mortality and Morbidity Statistics in Europe. Eur Heart J. 1997; 18(12): 1231-48.
2. Norris RM. Fatality outside hospital from acute coronary events in three British health districts, 1994-5. United Kingdom Heart Attack Study Collaborative Group. BMJ. 1998; 316(7137): 1065-70.
3. Chambless L, Keil U, Dobson A, Mahonen M, Kuulasmaa K, Rajakangas AM, et al. Population versus clinical view of case fatality from acute coronary heart disease: results from the WHO MONICA Project 1985-1990. Multinational MONItoring of Trends and Determinants in CArdiovascular Disease. Circulation. 1997; 96(11): 3849-59.
4. The Swedish Resuscitation Council [homepage on the Internet]. Nationellt register för hjärtstopp 2006 [cited 2007 Nov 1]. Available from: www.hlr.nu/skrivetom_hlr/nat_reg_out_hosp/register 2006.pdf
5. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the "chain of survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation. 1991; 83(5): 1832-47.
6. Kuisma M, Maatta T. Out-of-hospital cardiac arrests in Helsinki: Utstein style reporting. Heart. 1996; 76(1): 18-23.
7. Holmberg M, Holmberg S, Herlitz J. The problem of out-of-hospital cardiac-arrest prevalence of sudden death in Europe today. Am J Cardiol. 1999; 83(5B): 88D-90D.
8. Fairbanks RJ, Shah MN, Lerner EB, Ilangovan K, Pennington EC, Schneider SM. Epidemiology and outcomes of out-of-hospital cardiac arrest in Rochester, New York. Resuscitation. 2007; 72(3): 415-24.
9. Fridman M, Barnes V, Whyman A, Currell A, Bernard S, Walker T, et al. A model of survival following pre-hospital cardiac arrest based on the Victorian Ambulance Cardiac Arrest Register. Resuscitation. 2007. Epub. 2007 Nov 1.
10. Grmec S, Krizmaric M, Mally S, Kozelj A, Spindler M, Lesnik B. Utstein style analysis of out-of-hospital cardiac arrest -bystander CPR and end expired carbon dioxide. Resuscitation. 2007; 72(3): 404-14.

11. Kette F, Pellis T. Increased survival despite a reduction in out-of-hospital ventricular fibrillation in north-east Italy. Resuscitation. 2007; 72(1): 52-8.
12. Dunne RB, Compton S, Zalenski RJ, Swor R, Welch R, Bock BF. Outcomes from out-of-hospital cardiac arrest in Detroit. Resuscitation. 2007; 72(1): 59-65.
13. Cummins RO, Chamberlain DA, Abramson NS, Allen M, Baskett PJ, Becker L, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. A statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation. 1991; 84(2): 960-75.
14. Engdahl J, Holmberg M, Karlson BW, Luepker R, Herlitz J. The epidemiology of out-of-hospital 'sudden' cardiac arrest. Resuscitation. 2002; 52(3): 235-45.
15. Socialstyrelsen [homepage on the internet]. Socialstyrelsens riktlinjer för hjärtsjukvård 2004. Det medicinska fakta-dokumentet. Riktlinjer för kranskärlsvård 2004 [pdf]: [cited 2005-02-14] available from: http://www.socialstyrelsen.se
16. Goraya TY, Jacobsen SJ, Kottke TE, Frye RL, Weston SA, Roger VL. Coronary heart disease death and sudden cardiac death: a 20-year population-based study. Am J Epidemiol. 2003; 157(9): 763-70.
17. Rea TD, Pearce RM, Raghunathan TE, Lemaitre RN, Sotoodehnia N, Jouven X, et al. Incidence of out-of-hospital cardiac arrest. Am J Cardiol. 2004; 93(12): 1455-60.
18. Abildstrom SZ, Rask-Madsen C, Ottesen MM, Andersen PK, Rosthoj S, Torp-Pedersen C, et al. Impact of age and sex on sudden cardiovascular death following myocardial infarction. Heart. 2002; 88(6): 573-8.
19. American Heart Association. Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC). JAMA. 1974; 227(7): 837-66.
20. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). Part VIII: Medicolegal considerations and recommendations. JAMA. 1986; 255(21): 2979-84.
21. Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. Resuscitation. 1997; 35(1): 23-6.
22. Eberle B, Dick WF, Schneider T, Wisser G, Doetsch S, Tzanova I. Checking the carotid pulse check: diagnostic accuracy of first responders in patients with and without a pulse. Resuscitation. 1996; 33(2): 107-16.

23. Cummins RO, Hazinski MF. Guidelines based on fear of type II (false-negative) errors. Why we dropped the pulse check for lay rescuers. Resuscitation. 2000; 46(1-3): 439-42.
24. Handley AJ, Monsieurs KG, Bossaert LL. European Resuscitation Council Guidelines 2000 for Adult Basic Life Support. A statement from the Basic Life Support and Automated External Defibrillation Working Group(1) and approved by the Executive Committee of the European Resuscitation Council. Resuscitation. 2001;48(3): 199-205.
25. Handley AJ, Koster R, Monsieurs K, Perkins GD, Davies S, Bossaert L. European Resuscitation Council guidelines for resuscitation 2005. Section 2. Adult basic life support and use of automated external defibrillators. Resuscitation. 2005; 67 Suppl 1: S7-23.
26. Eisenberg MS. Life in Balance. Emergency medicine and the quest to reverse sudden death. New York: Oxford University Press;1997.
27. Kouwenhoven WB, Jude JR, Knickerbocker GG. Closed-chest cardiac massage. JAMA. 1960; 173: 1064-7.
28. Handley AJ, Bahr J, Baskett P, Bossaert L, Chamberlain D, Dick W, et al. The 1998 European Resuscitation Council guidelines for adult single rescuer basic life support: A statement from the Working Group on Basic Life Support, and approved by the executive committee. Resuscitation. 1998; 37(2): 67-80.
29. Ma MH, Hwang JJ, Lai LP, Wang SM, Huang GT, Shyu KG, et al. Transesophageal echocardiographic assessment of mitral valve position and pulmonary venous flow during cardiopulmonary resuscitation in humans. Circulation. 1995; 92(4): 854-61.
30. Wik L, Hansen TB, Fylling F, Steen T, Vaagenes P, Auestad BH, et al. Delaying defibrillation to give basic cardio-pulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. JAMA. 2003; 289(11): 1389-95.
31. Steen S, Liao Q, Pierre L, Paskevicius A, Sjoberg T. The critical importance of minimal delay between chest compressions and subsequent defibrillation: a haemodynamic explanation. Resuscitation. 2003; 58(3): 249-58.
32. Kern KB. Limiting interruptions of chest compressions during cardiopulmonary resuscitation. Resuscitation 2003;58(3):273-4.
33. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. Circulation. 2002; 105(5): 645-9.
34. Kellum MJ, Kennedy KW, Ewy GA. Cardiocerebral resuscitation improves survival of patients with out-of-hospital cardiac arrest. Am J Med. 2006; 119(4): 335-40.

35. American Medical Association. JAMA Reference Directories. JAMA. 1974; 230(8): 1132-7.
36. European Resuscitation Council. Part 1: introduction to the International Guidelines 2000 for CPR and ECC. A consensus on science. Resuscitation. 2000; 46(1-3): 3-15.
37. Axelsson AB, Herlitz J, Holmberg S, Thoren AB. A nationwide survey of CPR training in Sweden: Foreign born and unemployed are not reached by training programmes. Resuscitation. 2006.
38. de Vreede-Swagemakers JJ, Gorgels AP, Dubois-Arbouw WI, Dalstra J, Daemen MJ, van Ree JW, et al. Circumstances and causes of out-of-hospital cardiac arrest in sudden death survivors. Heart. 1998; 79(4): 356-61.
39. Herlitz J, Engdahl J, Svensson L, Young M, Angquist KA, Holmberg S. Changes in demographic factors and mortality after out-of-hospital cardiac arrest in Sweden. Coron Artery Dis. 2005; 16(1): 51-57.
40. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Circulation. 2004; 110(21): 3385-97.
41. Sedgwick ML, Dalziel K, Watson J, Carrington DJ, Cobbe SM. Performance of an established system of first responder out-of-hospital defibrillation. The results of the second year of the Heartstart Scotland Project in the 'Utstein Style'. Resuscitation. 1993; 26(1): 75-88.
42. Cummins RO, Eisenberg MS, Hallstrom AP, Litwin PE. Survival of out-of-hospital cardiac arrest with early initiation of cardiopulmonary resuscitation. Am J Emerg Med. 1985; 3(2): 114-9.
43. Cobb LA. Variability in resuscitation rates for out-of-hospital cardiac arrest. Arch Intern Med. 1993; 153(10): 1165-6.
44. Ekstrom L, Herlitz J, Wennerblom B, Axelsson A, Bang A, Holmberg S. Survival after cardiac arrest outside hospital over a 12-year period in Gothenburg. Resuscitation. 1994; 27(3): 181-7.
45. Waalewijn RA. Out-of-hospital Circulatory Arrest: Factors Determining the outcome [dissertation]. Amsterdam: Universiteit van Amsterdam; 2002.

46. Jackson RE, Swor RA. Who gets bystander cardiopulmonary resuscitation in a witnessed arrest? Acad Emerg Med. 1997; 4(6): 540-4.
47. Litwin PE, Eisenberg MS, Hallstrom AP, Cummins RO. The location of collapse and its effect on survival from cardiac arrest. Ann Emerg Med. 1987; 16(7): 787-91.
48. Herlitz J, Eek M, Holmberg M, Engdahl J, Holmberg S. Characteristics and outcome among patients having out of hospital cardiac arrest at home compared with elsewhere. Heart. 2002; 88(6): 579-82.
49. Herlitz J, Engdahl J, Svensson L, Angquist KA, Young M, Holmberg S. Factors associated with an increased chance of survival among patients suffering from an out-of-hospital cardiac arrest in a national perspective in Sweden. Am Heart J. 2005; 149(1): 61-6.
50. Holmberg M, Holmberg S, Herlitz J. Effect of bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients in Sweden. Resuscitation. 2000; 47(1): 59-70.
51. Herlitz J, Engdahl J, Svensson L, Young M, Angquist KA, Holmberg S. Decrease in the occurrence of ventricular fibrillation as the initially observed arrhythmia after out-of-hospital cardiac arrest during 11 years in Sweden. Resuscitation. 2004; 60(3): 283-90.
52. Swor RA, Jackson RE, Compton S, Domeier R, Zalenski R, Honeycutt L, et al. Cardiac arrest in private locations: different strategies are needed to improve outcome. Resuscitation. 2003; 58(2): 171-6.
53. Herlitz J, Eek M, Engdahl J, Holmberg M, Holmberg S. Factors at resuscitation and outcome among patients suffering from out of hospital cardiac arrest in relation to age. Resuscitation. 2003; 58(3): 309-17.
54. Swor RA, Jackson RE, Tintinalli JE, Pirrallo RG. Does advanced age matter in outcomes after out-of-hospital cardiac arrest in community-dwelling adults? Acad Emerg Med. 2000; 7(7): 762-8.
55. Bonnin MJ, Pepe PE, Clark PS, Jr. Survival in the elderly after out-of-hospital cardiac arrest. Crit Care Med. 1993; 21(11): 1645-51.
56. Herlitz J, Engdahl J, Svensson L, Young M, Angquist KA, Holmberg S. Is female sex associated with increased survival after out-of-hospital cardiac arrest? Resuscitation. 2004; 60(2): 197-203.
57. Engdahl J, Bang A, Karlson BW, Lindqvist J, Herlitz J. Characteristics and outcome among patients suffering from out of hospital cardiac arrest of non-cardiac aetiology. Resuscitation. 2003; 57(1): 33-41.

58. Waalewijn RA, de Vos R, Koster RW. Out-of-hospital cardiac arrests in Amsterdam and its surrounding areas: results from the Amsterdam resuscitation study (ARREST) in 'Utstein' style. Resuscitation. 1998; 38(3): 157-67.
59. Holmberg M, Holmberg S, Herlitz J, Gardelov B. Survival after cardiac arrest outside hospital in Sweden. Swedish Cardiac Arrest Registry. Resuscitation. 1998; 36(1): 29-36.
60. Herlitz J, Ekstrom L, Wennerblom B, Axelsson A, Bang A, Holmberg S. Effect of bystander initiated cardiopulmonary resuscitation on ventricular fibrillation and survival after witnessed cardiac arrest outside hospital. Br Heart J. 1994; 72(5): 408-12.
61. Herlitz J, Bahr J, Fischer M, Kuisma M, Lexow K, Thorgeirsson G. Resuscitation in Europe: a tale of five European regions. Resuscitation. 1999; 41(2): 121-31.
62. Waalewijn RA, Nijpels MA, Tijssen JG, Koster RW. Prevention of deterioration of ventricular fibrillation by basic life support during out-of-hospital cardiac arrest. Resuscitation. 2002; 54(1): 31-6.
63. Cobb LA, Fahrenbruch CE, Olsufka M, Copass MK. Changing incidence of out-of-hospital ventricular fibrillation, 1980-2000. JAMA. 2002; 288(23): 3008-13.
64. Kuisma M, Repo J, Alaspaa A. The incidence of out-of-hospital ventricular fibrillation in Helsinki, Finland, from 1994 to 1999. Lancet. 2001; 358(9280): 473-4.
65. Herlitz J, Andersson E, Bang A, Engdahl J, Holmberg M, Lindqvist J, et al. Experiences from treatment of out-of-hospital cardiac arrest during 17 years in Goteborg. Eur Heart J. 2000; 21(15): 1251-8.
66. Waalewijn RA, Tijssen JG, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST). Resuscitation. 2001; 50(3): 273-9.
67. Dowie R, Campbell H, Donohoe R, Clarke P. 'Event tree' analysis of out-of-hospital cardiac arrest data: confirming the importance of bystander CPR. Resuscitation 2003;56(2):173-81.
68. Holmberg M, Holmberg S, Herlitz J. Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. Eur Heart J. 2001; 22(6): 511-9.
69. Chamberlain DA, Hazinski MF. Education in resuscitation: an ILCOR symposium: Utstein Abbey: Stavanger, Norway: June 22-24, 2001. Circulation. 2003; 108(20): 2575-94.
70. Brennan RT, Braslow A. Are we training the right people yet? A survey of participants in public cardiopulmonary resuscitation classes. Resuscitation. 1998; 37(1): 21-5.

71. Axelsson A, Thoren A, Holmberg S, Herlitz J. Attitudes of trained Swedish lay rescuers toward CPR performance in an emergency. A survey of 1012 recently trained CPR rescuers. Resuscitation. 2000; 44(1): 27-36.
72. Richardson ME, Lie KG. Cardiopulmonary resuscitation training for family members of patients on cardiac rehabilitation programmes in Scotland. Resuscitation. 1999;40(1):11-9.
73. Platz E, Scheatzle MD, Pepe PE, Dearwater SR. Attitudes towards CPR training and performance in family members of patients with heart disease. Resuscitation. 2000; 47(3): 273-80.
74. Lester C, Donnelly P, Assar D. Community life support training: does it attract the right people? Public Health. 1997; 111(5): 293-6.
75. Moser DK, Dracup K. Impact of cardiopulmonary resuscitation training on perceived control in spouses of recovering cardiac patients. Res Nurs Health. 2000; 23(4): 270-8.
76. Dracup K, Guzy PM, Taylor SE, Barry J. Cardiopulmonary resuscitation (CPR) training. Consequences for family members of high-risk cardiac patients. Arch Intern Med. 1986; 146(9): 1757-61.
77. Dracup K, Heaney DM, Taylor SE, Guzy PM, Breu C. Can family members of high-risk cardiac patients learn cardiopulmonary resuscitation? Arch Intern Med. 1989; 149(1): 61-4.
78. Dracup K, Moser DK, Guzy PM, Taylor SE, Marsden C. Is cardiopulmonary resuscitation training deleterious for family members of cardiac patients? Am J Public Health. 1994; 84(1):116-8.
79. Dracup K, Moser DK, Taylor SE, Guzy PM. The psychological consequences of cardiopulmonary resuscitation training for family members of patients at risk for sudden death. Am J Public Health. 1997; 87(9): 1434-9.
80. Kliegel A, Scheinecker W, Sterz F, Eisenburger P, Holzer M, Laggner AN. The attitudes of cardiac arrest survivors and their family members towards CPR courses. Resuscitation. 2000; 47(2): 147-54.
81. Pane GA, Salness KA. Targeted recruitment of senior citizens and cardiac patients to a mass CPR training course. Ann Emerg Med. 1989; 18(2): 152-4.
82. McLauchlan CA, Ward A, Murphy NM, Griffith MJ, Skinner DV, Camm AJ. Resuscitation training for cardiac patients and their relatives - its effect on anxiety. Resuscitation. 1992; 24(1): 7-11.
83. Ingram S, Maher V, Bennett K, Gormley J. The effect of cardiopulmonary resuscitation training on psychological variables of cardiac rehabilitation patients. Resuscitation. 2006; 71(1): 89-96.

84. Sigsbee M, Geden EA. Effects of anxiety on family members of patients with cardiac disease learning cardiopulmonary resuscitation. Heart Lung. 1990; 19(6): 662-5.
85. Swor R, Khan I, Domeier R, Honeycutt L, Chu K, Compton S. CPR training and CPR performance: do CPR-trained bystanders perform CPR? Acad Emerg Med. 2006;13(6):596-601.
86. Van Hoeyweghen RJ, Bossaert LL, Mullie A, Calle P, Martens P, Buylaert WA, et al. Quality and efficiency of bystander CPR. Belgian Cerebral Resuscitation Study Group. Resuscitation. 1993; 26(1): 47-52.
87. Wik L, Steen PA, Bircher NG. Quality of bystander cardio-pulmonary resuscitation influences outcome after prehospital cardiac arrest. Resuscitation. 1994; 28(3): 195-203.
88. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA. 1995; 274(24): 1922-5.
89. Jansen JJ, Berden HJ, van der Vleuten CP, Grol RP, Rethans J, Verhoeff CP. Evaluation of cardiopulmonary resuscitation skills of general practitioners using different scoring methods. Resuscitation. 1997; 34(1): 35-41.
90. Nyman J, Sihvonen M. Cardiopulmonary resuscitation skills in nurses and nursing students. Resuscitation. 2000;47(2): 179-84.
91. Brennan RT, Braslow A. Skill mastery in public CPR classes. Am J Emerg Med. 1998; 16(7): 653-7.
92. Donnelly PD, Lester CA, Morgan CL, Assar D. Evaluating CPR performance in basic life support: the VIDRAP protocol. Resuscitation. 1998; 36(1): 51-7.
93. Donnelly P, Assar D, Lester C. A comparison of manikin CPR performance by lay persons trained in three variations of basic life support guidelines. Resuscitation. 2000; 45(3): 195-9.
94. van Kalmthout PM, Speth PA, Rutten JR, Vonk JT. Evaluation of lay skills in cardiopulmonary resuscitation. Br Heart J. 1985; 53(5): 562-6.
95. Kaye W, Rallis SF, Mancini ME, Linhares KC, Angell ML, Donovan DS, et al. The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructor, not the learner or the curriculum. Resuscitation. 1991; 21(1): 67-87.
96. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, et al. Randomised controlled trials of staged teaching for basic life support. 1. Skill acquisition at bronze stage. Resuscitation. 2000; 45(1): 7-15.

97. Chamberlain D, Smith A, Woollard M, Colquhoun M, Handley AJ, Leaves S, et al. Trials of teaching methods in basic life support (3): comparison of simulated CPR performance after first training and at 6 months, with a note on the value of re-training. Resuscitation. 2002; 53(2): 179-87.
98. Braslow A, Brennan RT, Newman MM, Bircher NG, Batcheller AM, Kaye W. CPR training without an instructor: development and evaluation of a video self-instructional system for effective performance of cardiopulmonary resuscitation. Resuscitation. 1997; 34(3): 207-20.
99. Batcheller AM, Brennan RT, Braslow A, Urrutia A, Kaye W. Cardio-pulmonary resuscitation performance of subjects over forty is better following half-hour video self-instruction compared to traditional four-hour classroom training. Resuscitation. 2000; 43(2): 101-10.
100. Isbye DL, Rasmussen LS, Lippert FK, Rudolph SF, Ringsted CV. Laypersons may learn basic life support in 24min using a personal resuscitation manikin. Resuscitation. 2006; 69(3): 435-42.
101. Lynch B, Einspruch EL, Nichol G, Becker LB, Aufderheide TP, Idris A. Effectiveness of a 30-min CPR self-instruction program for lay responders: a controlled randomized study. Resuscitation. 2005; 67(1): 31-43.
102. Einspruch EL, Lynch B, Aufderheide TP, Nichol G, Becker L. Retention of CPR skills learned in a traditional AHA Heartsaver course versus 30-min video self-training: A con-trolled randomized study. Resuscitation. 2007;74(3): 476-86.
103. Wik L, Myklebust H, Auestad BH, Steen PA. Retention of basic life support skills 6 months after training with an automated voice advisory manikin system without instructor involvement. Resuscitation. 2002; 52(3): 273-9.
104. Wik L, Myklebust H, Auestad BH, Steen PA. Twelve-month retention of CPR skills with automatic correcting verbal feedback. Resuscitation. 2005; 66(1): 27-30.
105. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, et al. A rationale for staged teaching of basic life support. Resuscitation. 1998; 39(3): 137-43.
106. Smith A, Colquhoun M, Woollard M, Handley AJ, Kern KB, Chamberlain D. Trials of teaching methods in basic life support (4): comparison of simulated CPR performance at unannounced home testing after conventional or staged training. Resuscitation. 2004; 61(1): 41-7.

107. Chamberlain D, Smith A, Colquhoun M, Handley AJ, Kern KB, Woollard M. Randomised controlled trials of staged teaching for basic life support: 2. Comparison of CPR performance and skill retention using either staged instruction or conventional training. Resuscitation. 2001; 50(1): 27-37.
108. The Swedish Resuscitation Council [homepage on the Internet]. Utbildningsprogram HLR. [cited 2007 Nov 1]. Available from: http://www.hlr.nu/index.php?q=node/15
109. Berden HJ, Bierens JJ, Willems FF, Hendrick JM, Pijls NH, Knape JT. Resuscitation skills of lay public after recent training. Ann Emerg Med. 1994; 23(5): 1003-8.
110. Brennan RT, Braslow A, Batcheller AM, Kaye W. A reliable and valid method for evaluating cardiopulmonary resuscitation training outcomes. Resuscitation. 1996; 32(2): 85-93.
111. Monsieurs KG, De Regge M, Vogels C, Calle PA. Improved basic life support performance by ward nurses using the CAREvent Public Access Resuscitator (PAR) in a simulated setting. Resuscitation. 2005; 67(1): 45-50.
112. Makinen M, Aune S, Niemi-Murola L, Herlitz J, Varpula T, Nurmi J, et al. Assessment of CPR-D skills of nurses in Goteborg, Sweden and Espoo, Finland: Teaching leadership makes a difference. Resuscitation. 2007; 72(2): 264-9.
113. The Basic Life Support Working Party of the European Resuscitation Council. Guidelines for basic life support. Resuscitation. 1992; 24(2): 103-10.
114. Kvale S. Interviews: an introduction to qualitative research interviewing. Thousand Oaks, Calif: Sage; 1996.
115. Patton MQ. Qualitative Research & Evaluation Methods. 3 ed. London: Sage Publication; 2002.
116. Krippendorff K. Content Analysis. An Introduction to Its Methodology. 2nd ed. London: Sage Publications; 2004.
117. Agard A, Hermeren G, Herlitz J. Should cardiopulmonary resuscitation be performed on patients with heart failure? The role of the patient in the decision-making process. J Intern Med. 2000; 248(4): 279-86.
118. Schonwetter RS, Teasdale TA, Taffet G, Robinson BE, Luchi RJ. Educating the elderly: cardiopulmonary resuscitation decisions before and after intervention. J Am Geriatr Soc. 1991; 39(4): 372-7.
119. Kerridge IH, Pearson SA, Rolfe IE, Lowe M, McPhee JR. Impact of written information on knowledge and preferences for cardiopulmonary resuscitation. Med J Aust. 1999; 171(5): 239-42.

120. Murphy DJ, Burrows D, Santilli S, Kemp AW, Tenner S, Kreling B, et al. The influence of the probability of survival on patients' preferences regarding cardiopulmonary resuscitation. N Engl J Med. 1994; 330(8): 545-9.
121. Jones GK, Brewer KL, Garrison HG. Public expectations of survival following cardiopulmonary resuscitation. Acad Emerg Med. 2000; 7(1): 48-53.
122. van Mil AH, van Klink RC, Huntjens C, Westendorp RG, Stiggelbout AM, Meinders AE, et al. Cardiopulmonary resuscitation preferences in Dutch community-dwelling and hospitalized elderly people: an interaction between gender and quality of life. Med Decis Making. 2000; 20(4): 423-9.
123. Schonwetter RS, Walker RM, Kramer DR, Robinson BE. Resuscitation decision making in the elderly: the value of outcome data. J Gen Intern Med. 1993; 8(6): 295-300.
124. Hansdottir H, Gruman C, Curry L, Judge JO. Preferences for CPR among the elderly: the influence of attitudes and values. Conn Med. 2000; 64(10): 625-30.
125. Chu KH, May CR, Clark MJ, Breeze KM. CPR training in households of patients with chest pain. Resuscitation. 2003; 57(3): 257-68.
126. Keim SM, Anderson K, Siegel E, Spaite DW, Valenzuela TD. Factors associated with CPR certification within an elderly community. Resuscitation. 2001; 51(3): 269-74.
127. Swor R, Compton S, Farr L, Kokko S, Vining F, Pascual R, et al. Perceived self-efficacy in performing and willingness to learn cardiopulmonary resuscitation in an elderly population in a suburban community. Am J Crit Care. 2003; 12(1): 65-70.
128. Hansson Scherman M. Vägra vara sjuk. [dissertation] Göteborg: Göteborg University; 1994
129. Heidenreich JW, Higdon TA, Kern KB, Sanders AB, Berg RA, Niebler R, et al. Single-rescuer cardiopulmonary resuscitation: 'two quick breaths' - an oxymoron. Resuscitation. 2004; 62(3): 283-9.
130. Wik L, Kramer-Johansen J, Myklebust H, Sorebo H, Svensson L, Fellows B, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. JAMA. 2005; 293(3): 299-304.
131. Turner I, Turner S. Optimum cardiopulmonary resuscitation for basic and advanced life support: a simulation study. Resuscitation. 2004; 62(2): 209-17.
132. Babbs CF, Kern KB. Optimum compression to ventilation ratios in CPR under realistic, practical conditions: a physiological and mathematical analysis. Resuscitation. 2002; 54(2): 147-57.

133. Olasveengen TM, Wik L, Kramer-Johansen J, Sunde K, Pytte M, Steen PA. Is CPR quality improving? A retrospective study of out-of-hospital cardiac arrest. Resuscitation. 2007; 75(2): 260-6.
134. Yu T, Weil MH, Tang W, Sun S, Klouche K, Povoas H, et al. Adverse outcomes of interrupted precordial compression during automated defibrillation. Circulation. 2002; 106(3): 368-72.
135. Bellamy RF, DeGuzman LR, Pedersen DC. Coronary blood flow during cardiopulmonary resuscitation in swine. Circulation. 1984; 69(1): 174-80.
136. Maier GW, Newton JR, Jr., Wolfe JA, Tyson GS, Jr., Olsen CO, Glower DD, et al. The influence of manual chest compression rate on hemodynamic support during cardiac arrest: high-impulse cardiopulmonary resuscitation. Circulation. 1986; 74(6 Pt 2): IV51-9.
137. Maier GW, Tyson GS, Jr., Olsen CO, Kernstein KH, Davis JW, Conn EH, et al. The physiology of external cardiac massage: high-impulse cardiopulmonary resuscitation. Circulation. 1984; 70(1): 86-101.
138. Halperin HR, Tsitlik JE, Guerci AD, Mellits ED, Levin HR, Shi AY, et al. Determinants of blood flow to vital organs during cardiopulmonary resuscitation in dogs. Circulation. 1986; 73(3): 539-50.
139. Paradis NA, Martin GB, Rivers EP, Goetting MG, Appleton TJ, Feingold M, et al. Coronary perfusion pressure and the return of spontaneous circulation in human cardiopulmonary resuscitation. JAMA. 1990; 263(8): 1106-13.
140. Tomlinson AE, Nysaether J, Kramer-Johansen J, Steen PA, Dorph E. Compression force-depth relationship during out-of-hospital cardiopulmonary resuscitation. Resuscitation. 2007; 72(3): 364-70.
141. Steen S, Liao Q, Pierre L, Paskevicius A, Sjoberg T. Evaluation of LUCAS, a new device for automatic mechanical compression and active decompression resuscitation. Resuscitation. 2002; 55(3): 285-99.
142. Wik L, Naess PA, Ilebekk A, Nicolaysen G, Steen PA. Effects of various degrees of compression and active decompression on haemodynamics, end-tidal CO2, and ventilation during cardiopulmonary resuscitation of pigs. Resuscitation. 1996; 31(1): 45-57.
143. Baskett P, Nolan J, Parr M. Tidal volumes which are perceived to be adequate for resuscitation. Resuscitation. 1996; 31(3): 231-4.
144. Langhelle A, Sunde K, Wik L, Steen PA. Arterial blood-gases with 500 versus 1000-ml tidal volumes during out-of-hospital CPR. Resuscitation. 2000; 45(1): 27-33.
145. Dorph E, Wik L, Steen PA. Arterial blood gases with 700 ml tidal volumes during out-of-hospital CPR. Resuscitation. 2004;61(1):23-7.

146. Idris AH, Becker LB, Fuerst RS, Wenzel V, Rush WJ, Melker RJ, et al. Effect of ventilation on resuscitation in an animal model of cardiac arrest. Circulation. 1994; 90(6): 3063-9.
147. Idris AH. Reassessing the need for ventilation during CPR. Ann Emerg Med. 1996; 27(5): 569-75.
148. Kern KB, Hilwig RW, Berg RA, Ewy GA. Efficacy of chest compression-only BLS CPR in the presence of an occluded airway. Resuscitation. 1998; 39(3): 179-88.
149. Lurie KG, Zielinski T, McKnite S, Aufderheide T, Voelckel W. Use of an inspiratory impedance valve improves neurologically intact survival in a porcine model of ventricular fibrillation. Circulation. 2002; 105(1): 124-9.
150. Aufderheide TP, Sigurdsson G, Pirrallo RG, Yannopoulos D, McKnite S, von Briesen C, et al. Hyperventilation-induced hypotension during cardiopulmonary resuscitation. Circulation. 2004; 109(16): 1960-5.
151. Pitts S, Kellermann AL. Hyperventilation during cardiac arrest. Lancet. 2004; 364(9431): 313-5.
152. Berg RA, Sanders AB, Kern KB, Hilwig RW, Heidenreich JW, Porter ME, et al. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. Circulation. 2001; 104(20): 2465-70.
153. Sanders AB, Kern KB, Berg RA, Hilwig RW, Heidenrich J, Ewy GA. Survival and neurologic outcome after cardiopulmonary resuscitation with four different chest compression-ventilation ratios. Ann Emerg Med. 2002; 40(6): 553-62.
154. Bossaert L, editor. European Resuscitation Council Guidelines for Resuscitation. Antwerp: University of Antwerp; 1998.
155. Anonymous. Part 3: adult basic life support. European Resuscitation Council. Resuscitation. 2000; 46(1-3): 29-71.
156. Castren M, Kuisma M, Serlachius J, Skrifvars M. Do health care professionals report sudden cardiac arrest better than laymen? Resuscitation. 2001; 51(3): 265-8.
157. Nolan J. European Resuscitation Council guidelines for resuscitation 2005. Section 1. Introduction. Resuscitation. 2005; 67 Suppl 1: S3-6.
158. Deedwania P. Global risk assessment in the presymptomatic patient. Am J Cardiol. 2001; 88(7B): 17J-22J.
159. King KB, McGuire MA. Symptom presentation and time to seek care in women and men with acute myocardial infarction. Heart Lung. 2007; 36(4): 235-43.

160. Horne R, James D, Petrie K, Weinman J, Vincent R. Patients' interpretation of symptoms as a cause of delay in reaching hospital during acute myocardial infarction. Heart. 2000; 83(4): 388-93.
161. Canto JG, Shlipak MG, Rogers WJ, Malmgren JA, Frederick PD, Lambrew CT, et al. Prevalence, clinical characteristics, and mortality among patients with myocardial infarction presenting without chest pain. JAMA. 2000; 283(24): 3223-9.
162. Pattenden J, Watt I, Lewin RJ, Stanford N. Decision making processes in people with symptoms of acute myocardial infarction: qualitative study. BMJ. 2002; 324(7344): 1006-9.
163. Walsh JC, Lynch M, Murphy AW, Daly K. Factors influencing the decision to seek treatment for symptoms of acute myocardial infarction: an evaluation of the Self-Regulatory Model of illness behaviour. J Psychosom Res. 2004; 56(1): 67-73.
164. Johansson I, Swahn E, Stromberg A. Manageability, vulnerability and interaction: A qualitative analysis of acute myocardial infarction patients' conceptions of the event. Eur J Cardiovasc Nurs. 2007; 6(3): 184-91.
165. Alonzo AA, Reynolds NR. Responding to symptoms and signs of acute myocardial infarction - how do you educate the public?: a social-psychologic approach to intervention. Heart Lung. 1997; 26(4): 263-72.

Appendix

Checklist according to Brennan *et al*. [110] (p. 91) adjusted to the Swedish guidelines.

Item 1: Checks unresponsiveness by touching manikin and speaking loudly.
Must precede any intervention including opening the airway.

Item 2: Calls for help or indicates help should be called.
Must occur after check of unresponsiveness and before starting chest compressions.

Item 3: Opens airway using head-tilt/chin-lift:
Participant uses one hand to push down on forehead and other hand to lift the chin. There is obvious movement of the head. Nose may or may not be pinched.
Must precede a breathing check. (If the airway is opened for the first time to give breaths, do not count it as the open airway step).

Item 4: Checks breathing for *at least 3 seconds:* Participant places face near the manikin's face and looks at the chest.
Must occur before any breaths are given and airway must have been opened.

Item 5: Checks carotid pulse for *a minimum of 5 seconds:* Participant fingers on Adams apple and slips fingers into the groove, or uses an alternative method to establish correct position and then maintains position of fingers at least 5 seconds.
Must occur before any chest compressions.

Item 6: Attempts at least two breaths such as the chest rises at least one and not more than twice:
Must precede any chest compressions.

Item 7: Locates compression position. By 1) tracing outline of ribs and finding the place one finger above where the ribs comes together, 2) finding the xiphoid and placing two fingers above it, 3) baring the chest and visually finding a point on the sternum between the nipples.
Note: this item does not assess where the hands are ultimately positioned, only whether one of the three methods was used.