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Bystander Initiated and Dispatcher Assisted Cardiopulmonary Resuscitation in Out-of-hospital Cardiac Arrest

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ABSTRACT

Cardiac arrest (CA) is a common cause of death. In Sweden approximately 6 000- 10 000 people annually suffer a CA outside hospital. Cardiopulmonary resuscitation (CPR) can save lives in an out-of-hospital cardiac arrest (OHCA). The aim of this thesis was to describe various aspects of CPR and the emergency medical dispatcher (EMD) organisation to find approaches for enhancing bystander intervention in OHCA.

Methods and results: In **Study I,** 315 consecutive cases of OHCA during a 3-month period in 2004 were analysed to describe the frequency of as well as hindrance to dispatcher-assisted CPR. Seventy-six cases met the inclusion and exclusion criteria as witnessed, non-traumatic CA and the corresponding tapes recordings of the emergency calls were analyzed. Dispatchers offered bystanders telephone instructions for CPR in 47% (n=36) of cases. Only two bystanders were unwilling to perform CPR. Signs of breathing (agonal respiration) were described in 45% of cases. CPR was offered to 23% (n=10) of patients with agonal respiration versus 92% (n=23) of those without any form of breathing signs (p=0.001).
To evaluate whether tuition in recognition of agonal respiration will improve EMD recognition of CA and subsequent offers of assisted CPR by telephone (T-CPR) was addressed in **Study II.** In 255 consecutive cases of OHCA during the study period in 2006, 76 cases met the inclusion and exclusion criteria as witnessed, non-traumatic CA and the corresponding tape recordings of the emergency calls were analyzed. The findings from the 76 tape recordings from study I were used as a historical control group. The EMD offered CPR instructions in 36 (47%) calls before tuition compared to 52 (68%) calls after a 1-day tuition in agonal respiration (p=0.01). An increase was also shown after the tuition regarding offered dispatcher-assisted CPR in cases with agonal respiration, 23% (2004) vs. 56% (2006) (p=0.006).
To evaluate standard bystander CPR (mouth-to-mouth ventilation *with* chest compressions) versus chest compression only CPR by bystanders **Study III** included cases of OHCA who had received any form of bystander CPR and who had been reported to the Swedish Cardiac Arrest Register between 1990 and 2005. Crew witnessed cases of OHCA were excluded. Information as to type of CPR that had been given was missing in 1 465 (11%) patients. Among the remaining 11 275 patients, 8 209 had (73%) received standard CPR, whereas 1 145 patients (10%) had received compressions only. There was no significant difference in 1-month survival in patients who received standard CPR compared with those given compression only CPR.
In **Study IV** calls concerning possible cases of witnessed OHCA were randomized by EMDs to receive pre-arrival instructions of either compression only CPR or standard CPR. The primary end point was survival to 30 days. Data were collected between February 2005 to January 2009 for 3 809 patients. The intention-to-treat analysis included 1 276 patients who did meet the inclusion and exclusion criteria. Six hundred and eleven (620) patients were randomly assigned to receive instructions for compression only CPR and 656 patients for standard CPR. Survival in both groups was similar with 8.7% (54/620) of the patients who received compressions only CPR and 7.0% (46/656) in the standard CPR group being alive at 30 days (1.7 percentage points difference, 95% CI, -1.2% to 4.6%; $p < 0.30$).

Conlusions: EMDs do offer telephone guided CPR to bystanders in cases of OHCA but not to all those cases where it is indicated. Agonal respiration in association with CA is often a hindrance to offering T-CPR. Very few witnesses who were offered telephone-guidance for CPR refused to participate. A brief tutorial for EMDs comprising the signs and implications of agonal respiration led to a significantly higher proportion of bystanders who were offered T-CPR. In a register study of CPR in patients suffering OHCA no significant difference was found in 1-month survival in patients who received standard bystander CPR as compared to those given compressions only. A prospective randomized study showed no significant difference between pre-arrival instructions for compression only CPR compared to standard CPR in witnessed OHCA which gives further support to the hypothesis that compression-only CPR is the preferred method in bystander CPR.

Key Words: cardiac arrest, cardiopulmonary resuscitation, dispatcher-assisted CPR, agonal respiration

Ingenting är svårt när man kan det.
Skalman

To Arnold, Moa och Anton

LIST OF PUBLICATIONS

This thesis is based on the following four papers, which will be referred to by their Roman numerals.

I
Bohm K, Rosenqvist M, Hollenberg J, Biber B, Engerström L, Svensson L. Dispatcher-assisted telephone-guided cardiopulmonary resuscitation: an underused lifesaving system.
Eur J Emerg Med. 2007;14:256-259.

II
Bohm K. Stålhandske B, Rosenqvist M, Ulfvarson J, Hollenberg J , Svensson L. Tuition of emergency medical dispatchers in the recognition of agonal respiration increases the use of telephone assisted CPR.Resuscitation. 2009 Sep;80(9):1025-1028.

III
Bohm K, Rosenqvist M, Herlitz J, Svensson L. Survival is similar after standard treatment and chest compression only in out-of-hospital bystander cardiopulmonary resuscitation.
Circulation. 2007;116:2908-2912.

IV
Svensson L, Bohm K, Castrén M, Engerström L, Pettersson H, Herlitz J, Rosenqvist M. Compression-only CPR is not superior to standard CPR in out-of-hospital cardiac arrest. A randomized trial. Submitted

CONTENTS

ABBREVIATIONS AND GLOSSARY TERMS

Agonal respiration	The breathing pattern which can occur due to CA
AHA	American Heart Association
Basic CPR	An attempt to restore spontaneous circulation by using rescue breathing and chest compressions or chest compressions alone
Bystander	A lay person who witnesses or comes across a person in CA
Bystander CPR	An attempt to provide basic CPR by a lay person not part of the EMS
BLS	Basic life support. Includes recognition of CA, access to the EMS system and basic CPR
CA	Cardiac arrest
CI	Confidence interval
Compression-only CPR	Chest compression-only CPR without mouth-to-mouth ventilation
CPR	Cardiopulmonary resuscitation
EMD	Emergency medical dispatcher
EMCC	Emergency medical communication centre
EMS	Emergency medical service
ERC	European resuscitation council
NS	Non-significant (statistically)
OHCA	Out-of-hospital cardiac arrest
OR	Odds ratio
PEA	Pulseless electrical activity
ROSc	Return of spontaneous circulation
Standard CPR	Chest compression and mouth-to-mouth ventilation
T-CPR	Dispatcher-assisted CPR by telephone
VF	Ventricular fibrillation
VT	Ventricular tachycardia

INTRODUCTION

Cardiovascular disease is the most common cause of death. Globally, 30% of all deaths are due to cardiovascular disease (1). The most common mechanism of death due to ischemic heart disease is cardiac arrest (CA) the majority of which occurs outside hospital. Out-of-hospital cardiac arrest (OHCA) is therefore considered to account for most of the mortality in the western world (2). In Sweden with a population of 9 million inhabitants 6 000 – 10 000 people annually suffer an OHCA, and the majority of these is due to heart disease (3).

Cardiopulmonary resuscitation (CPR) can save lives in an OHCA by maintaining some circulation to vital organs until the arrival of the emergency medical services (EMS) with their means of further treatment with a defibrillator (4). During the last decade chest compressions have been given a more dominant role in CPR (5, 6) but still require further investigation. One part of this thesis therefore, addresses chest-compression-only-CPR performed by bystanders with and without assistance by emergency medical dispatchers (EMD).

To improve the present situation ways to increase the frequency of bystander CPR in OHCA must be found. Thus EMDs can give CPR-instructions to a bystander while calling for an ambulance enabling even the inexperienced bystander to start CPR (7). The second part of this thesis explores to what extent and how EMD identify OHCA and subsequently offers telephone instructions in CPR and whether specific tuition can improve this.

CARDIAC ARREST

Definition, etiology and epidemiology
"A CA is the abrupt cessation of normal circulation of the blood due to failure of the heart to contract effectively during systole"(8). According to another definition: "CA is the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness and apnoea (or agonal, gasping respirations)"(4).

Most OHCA are considered to be of cardiac origin and are caused by different conditions such as ischemic cardiac disease (coronary artery disease), primary arrhythmias, cardiomyopathies, valvular heart disease, congenital heart disease and primary cardiac electrical abnormalities. Of these ischemic cardiac conditions are the most common (9). Non-cardiac causes of CA include non traumatic bleeding, pulmonary embolism, lung disease, drug overdose, suffocation, drowning, trauma, drowning, stroke and the sudden infant death syndrome. These conditions are generally associated with a worse survival than arrests of cardiac origin (10). However, during absence of respiratory efforts with persistence of pulse which can occur in these conditions, the establishment of a patent airway and rescue breathing can maintain oxygenation and prevent a CA (11).

In the United States, almost 500 000 deaths per year are recognized as sudden CA, and 47 % of these occur outside hospital (12). In Europe it has been approximated that 275 000 people with OHCA anually are treated by EMS (13). An estimated 6000 to 10 000 persons per year suffer an OHCA in Sweden which has 9 million inhabitants (3).

A prospective North American observational study including 10 different sites presented a median incidence of EMS-treated OHCA to 52.1 per 100 000 persons. However, the interquartile range between sites was 48.0-70.1, revealing large regional differences (14). The incidence varies also among different groups of patients. Rea et al reported an overall OHCA incidence of 1.89/1000 person-years. This figure varied up to 30-fold across clinical subgroups: the incidence was 5.98/1000 person-years in subjects with any clinically diagnosed heart disease compared with 0.82/1000 person-years in persons without heart disease (15). The incidence in the two largest cities in Sweden is reported to be 0.34 and 0.47/1000 person-years respectively (16). In 2007 the mean age of OHCA patients in Sweden and US varies between 72 to 67 year and 30 to 41% were women (3, 17).

Symptoms and agonal respiration

The most common symptoms prior to an OHCA are angina pectoris, dyspnea, nausea or vomiting, dizziness and syncope (18). Following a sudden CA, blood flow to the brain will discontinue and the person collapses. During the following minutes the respiratory centres of the brain can still be active. Depending on the level of malfunction, breathing may become apneustic, gasping or ataxic (19). This "respiration" should not, however, be confused with spontaneous breathing.

The pattern and duration of agonal respiration can vary depending on whether the CA is truly sudden due to ventricular fibrillation (VF) or gradual (due to certain other arrhythmias or cardiogenic chock) (20). In the literature the term "gasping" is also used for this symptom.

Agonal respiration occurred in 40 % of calls reporting CA to an emergency medical communication centre (21, 22). Among witnessed cases the corresponding figure was 55%. Furthermore, in patients with VF as first recorded rhythm 56% had agonal respirations compared with 34% of patient without VF (21). Agonal respiration has also been shown to be strongly associated with survival. Two investigations have shown a survival rate of 27% and 28% of patients with agonal respiration compared with 9% and 8% of patients without agonal respiration (21, 23).

Clinically, agonal respiration has long been recognized but the understanding of the physiological and resuscitational consequences during CA is recent. In animal models of CA the majority of the animals show agonal respiration early during the course of the arrest (24, 25). Xie and colleagues studied the effects of agonal respiration during untreated VF in an animal model and found that agonal respiration during VF increased both ventilation and cardiac output compared to animals without agonal respiration (25). Others have shown that spontaneous agonal respiration decreases intracranial pressures and increases cerebral perfusion pressures (26). This mechanism might therefore explain the higher survival rate among OHCA patients with agonal respiration as reported by Clark et al and Bobrow et al (21, 23).

It is evidently more difficult to study agonal respiration in humans. Lay persons describe respiratory patterns of CA victims heterogeneously to EMS dispatchers; problematic or irregular breathing, barely or occasionally breathing, heavy or laboured breathing, gurgling noise, sighing, moaning, groaning and snorting (21, 22). Agonal respiration is probably one of the major obstacles for dispatchers to assist laymen with CPR, causing confusion for dispatchers in their attempts to identify cases of CA as well as preventing or delaying the initiation of dispatcher assisted CPR (27, 28, 23).

Survival

The reported overall survival after OHCA is 6.4% in the USA (29), 10.5% in Europe (13) and about 7% in Sweden (30). However, the reported survival varies widely within countries because of variations in patient characteristics, bystander participation, EMS organization and care. Furthermore, CA is ascertained and reported in different ways.

Many factors have been found to influence survival and include the first recorded heart rhythm (initial arrhythmia), time to treatment, location of the CA and if the CA was witnessed. Bystander CPR is also known to be a very important factor and will be described separately.

Initial arrhythmia

The following cardiac rhythms are usually found in CA: VF, ventricular tachycardia (VT), pulse-less electrical activity (PEA) or asystole (absence of ventricular activity). VF is a chaotic, rapid depolarisation and repolarisation. The heart loses its coordinated function and stops pumping blood effectively. The development of VF is not fully understood but it has been shown that VF usually is preceded by VT. Asystole is in turn often preceded by VF, which has deteriorated from coarse VF to fine VF to asystole (31). VF is strongly associated to survival in OHCA (32,33,34). Herlitz et al showed that survival was increased six times if the patient was found in VF at time of arrival of the EMS, even after adjusting for confounding factors (33). A decrease in the percentage of patients found in VF has been observed during the last decade but the underlying mechanisms are unknown (35), Resuscitation 2004JH] Survival of patients with asystole and PEA in OHCA is very low, 0-5% (36, 37) and 2-6%, respectively (38, 39).

Location

About 70% of the OHCAs occur in private locations. These patients are older, have less often had a witnessed CA, were less likely to be exposed to bystander CPR and were less likely to be found in VF (40, 41). The mean time to CPR in patients with witnessed CA outside their homes is shorter (42) and their chance to receive bystander CPR is four times greater and they are twice more likely to survive (43).

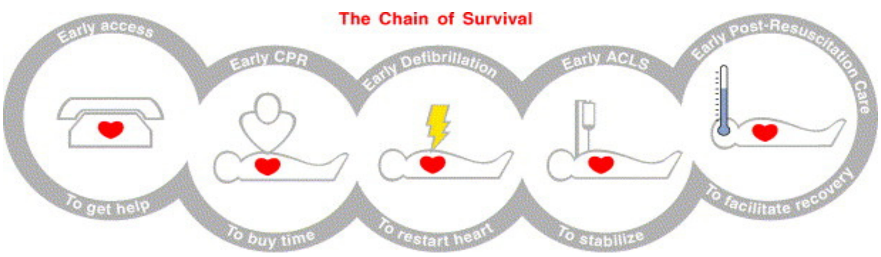
Treatment of OHCA

The history of cardiopulmonary resuscitation

Resuscitation techniques before the middle of the 20th century were very ineffective. During the 1950s and 1960s a number of studies led to the development of modern CPR (44). In 1961 chest compression was combined with the airway and breathing techniques to create modern CPR (44, 45). At the same time, external electric defibrillation was developed by Zoll et al and Lown et al. (46, 47). In 1966 a portable defibrillator had been developed and was feasible for use outside hospitals (48). Modern CPR includes chest compressions and mouth-to-mouth ventilation. According to the European Resuscitation Guidelines the ventilation/compression ratio has been modified during the last two decades from 2 ventilations/15 compressions to 30 compressions/2 ventilations (6, 49).

The chain-of-survival Figure 1
This well used concept comprises early access, early CPR, early defibrillation, early advanced cardiac life support and early post-resuscitation care (4). The best chance of survival is if this series of actions occurs as rapidly and efficiently as possible after an OHCA.

Figure 1. The chain-of-survival



Early access
The chain of survival begins with early access which includes the moment of collapse and recognition of the emergency, the decision and possibility to make the alarm call, interrogation of the caller by the EMD and the decision to send an emergency unit. All these steps add minutes to the critical interval between CA and treatment. The shorter this interval is, the better the outcome (50, 51).

Early CPR
The next link in the chain is initiation of basic CPR. This should start immediately following the recognition of CA. The benefit of early CPR has been shown repeatedly (33, 52, 53). Early CPR performed by bystanders is described further under a separate heading.

Early defibrillation
The vast majority of OHCA cases of cardiac origin, develop VF during the first minutes after collapse. That is the rationale for early defibrillation with the purpose to re-establish a normal spontaneous rhythm. Guidelines have stated that defibrillation should be performed as soon as possible in all patients with VF (49). However, it has now been shown that survival in OHCA improves when CPR is performed before defibrillation. This benefit was even more marked in patients with a response interval, i.e. time from call to EMS arrival, longer than 4-5 minutes (5, 52).

Early advanced cardiac life support
To further improve the chances of survival the early advanced life support link with endothracheal intubation and intravenous medication comes next. The organisation of and education in this advanced care varies markedly in different organisations and countries. The use of drugs such as vasopressors and anti-arrhythmic agents, in this setting has not been shown to increase survival, even though amiodarone has been shown to increase survival to hospital admission (54, 55). Adrenaline is, however, still recommended in the most recent guidelines (6). Nor did Stiell and colleagues find that survival improved with the addition of advanced cardiac life support to an optimized EMS system with effective defibrillation. They concluded that the EMS systems should prioritize bystander CPR and rapid-defibrillation programs (56).

Early post-resuscitation care
The last link in the "chain of survival" describes different aspects of treatment of the successfully resuscitated patient. Two investigations have resulted in the implementation of mild hypothermia for comatose survivors after VF (57, 58). Factors to be associated with improved in-hospital survival include optimising physiology (blood pressure, blood glucose, electrolytes and acid-base status), revascularisation (PCI, CABG and trombolysis), antiarrhythmic therapy (beta-blocking agents, amiodarone and implantable cardioverter-defibrillator) and anticonvulsant therapy (59).

Bystander CPR

Basic life support is described as "maintaining airway patency and supporting breathing and the circulation, without use of equipment other than a protective advice" (6). When this is performed by a lay person or a medically trained person if present at the scene but off duty, it is called Bystander CPR (60).

Early, i.e. before EMS arrival, bystander initiated CPR has been shown to increase survival significantly (33, 41, 61), and the explanation of this is believed to be that bystander CPR prolongs the electrical or shockable phase of VF (53, 62, 63). The benefit of bystander CPR seems to exist within a rather narrow time window to be most effective. It must be started within minutes from the moment of collapse (64) and the earlier the bystander CPR starts the better is the outcome (65). Sites with high rates of bystander CPR together with short EMS response times show the highest survival rates (66, 67).

The bystander is most often a spouse or a relative and the characteristics of bystanders are similar to those of patients (68). Those usually trained in CPR are often younger persons who do not live with anyone likely to suffer from CA (69, 70). Thus, even if extensive efforts are made to educate the citizens in CPR the majority of lay persons present in cases of CA are untrained in CPR and do not know what to do in this situation. However, when calling the alarm number for help, the EMD can give instructions in CPR and guide the bystander while waiting for the EMS. This offer is referred to as telephone-assisted CPR.

Chest compression-only CPR
Animal studies have shown no difference in survival and neurological outcome

between standard CPR and chest compressions only (71, 72). One investigation even showed adverse outcomes when interruptions in chest-compressions were made for mouth-to-mouth ventilation (73). The animals had an open airway in this study. However, even with totally occluded airways during the first six minutes of CA, compressions only resulted in higher survival (74). A few observational studies in humans have been performed and show similar survival with chest compressions only (compression-only CPR) when compared to standard CPR. (75, 76, 77). Hallstrom et al, in the so far only prospective randomized dispatcher study in humans, found no significant difference between standard CPR and compression-only CPR (7). The efficacy of compression-only CPR therefore requires further investigations.

When CA is caused by a cardiac condition, blood oxygenation levels are initially preserved and the primary problem is the lack of blood to the vital organs rather than low oxygen content in the blood. After a few minutes, the blood oxygen saturation, however, declines and adequate ventilation becomes a crucial component of successful resuscitation (45). It is, however, very difficult for a lay person to provide adequate ventilation (78) and a simplified protocol with chest compressions only, if effective, would be easier to learn as well as encourage bystanders to initiate CPR. Another relevant aspect is that many people hesitates to provide mout-to-mouth ventilation for health and safety reasons (70, 79, 80).

Compression-only CPR results in more compressions per minute and can be started more rapidly than standard CPR but the quality of the compressions is reported to be inferior (81). The American Heart Association considers that two breaths after every 15 chest compressions should use only 1.5-2 seconds per breath (82). This differs from the findings of a prospective randomized study with lay persons which showed that the interruptions for 2-breath ventilation required an average of 16 seconds (83).

The American Heart Association has recently recommended compression-only CPR in an advisory statement (84). This advice was mainly based on three retrospective observational studies published after the publications of the resuscitation guidelines of 2005 (75, 76, 85). The European Resuscitation Council has preferred to wait for more conclusive evidence before making similar changes in the guidelines (86).

THE EMERGENCY MEDICAL COMMUNICATION CENTRE (EMCC)

History

There has always been a need for a well functioning alarm system in dangerous situations. Historically, different strategies have been used to mediate alarms in cases of emergency such as shouting, smoke and fire signals, ringing bells or cannon shots. In 1792 the optical telegraph was presented in France. This method was further developed by an American, Samuel Morse, mostly known as the inventor of the Morse code that is still used today. Since the invention of the telephone by Alexander Graham Bell in 1876 use of this has been the most important way for making emergency calls, and it still is. The first alarm number “999” was implemented in London in 1937. It allowed telephone operators to recognise an incoming alarm call and the number was easy to remember by the public.

To improve the possibilities for Swedish citizens to contact different emergency services, a special alarm number was introduced in 1951. A new organisation was introduced in Sweden in 1973 in which the alarm number was transferred to county alarm centres and the local county council was responsible for co-ordination of fire and ambulance dispatches. In this new organisation the operators would interview the caller and switch the call to the appropriate service as well as giving advice and support to distressed callers while waiting for the emergency services.

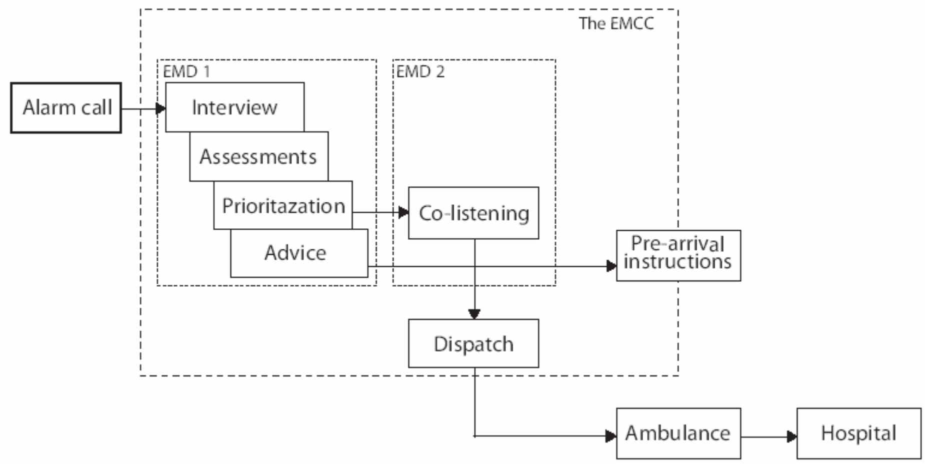
Some dispatchers came from the fire department dispatch centres. Applicants to the new organisation had to pass several tests, which included their ability to do several things simultaneously and under pressure. The dispatchers received a 3-week training course which included alarm and organisational planning, some medical education as well as technical training at the switchboard. To be able to rapidly obtain correct information during a call, the need for training of special interview techniques became apparent.

A shift in the dispatching technique was introduced in the 1980s. Old fashioned type of switchboards and maps were changed to a new computer system, Coord Com, including automatic number presenters and geographical co-ordinators. This system allowed for a more rapid dispatch of help. Furthermore, almost every ambulance is nowadays equipped with a satellite navigation system, GPS, which allows for immediate localisation of each ambulance (87).

The chain of prehospital emergency care

The EMS dispatch organisation is a part of the chain of prehospital emergency care and the emergency call is the first link in this chain (88). The goal of this chain of care is to create the best possible circumstances for the care seeker and put them in as good condition as possible for the next part of the chain. The EMD is the first response of the EMS system and the performance of the EMD is extremely important to achieve a low rate of misjudged cases (89, 90). An overview of the events occurring in the chain of prehospital emergency care, with focus on the EMCC, is displayed in Figure 1.

Figure 1. The chain of prehospital emergency care with focus on the Emergency Medical Communication Centre (EMCC). The emergency medical dispatcher (EMD) stays in contact with the caller and if needed gives instructions until the ambulance arrives. A second EMD listens to the call and dispatches appropriate vehicles simultaneously.



The current EMD organisation in Sweden

The public in Sweden nowadays reaches all community's relief resourses by one single call to the 112 emergency number. The alarm management and response control for these calls are handled by 18 well spread centers which co-operate with the ambulance service, fire department, police, poison information, sea rescue, air-sea rescue and mountain rescue. The EMS dispatch organisation (SOS Alarm AB) are responsible for prioritisation and directing the ambulance services.

Between in 2006-2008 the EMS dispatch organisation introduced a new technical platform, Zenit, for operative activities. Zenit is a national network solution; an EMCC in the northern parts of the country is able to serve the southern parts if necessary.

The EMS dispatch organisation is owned by the Government, counties and municipalities. The primary responsibility for the 112 number service involves receiving calls, interviewing, determining what has happened and forwarding relevant information to the appropriate authorities. Emergency calls that require the services of an ambulance or fire department are handled by the EMD. According to the regulations, the EMCC has to answer the emergency call within 8 seconds. The EMD staff has to complete a form for each alarm call which is saved for tree months. An extended storage of emergency medical records for up to several years is presently under consideration.

Each year the Swedish EMCC receive 780 000 emergency medical calls of which 34% are dispatched as priority 1, 48% as priority 2 and 18% as priority 3. Among the priority 1 cases 20-25% are due to accidents, whilst the remaining 75-80% are due to acute illness. Acute chest pain, dyspnoea, impaired consciousness and/or seizures are the most common causes of acute illness. The structure of EMCC in Sweden is shown in Table 1 (91).

Table 1. The structure of the EMD centres and corresponding EMS units in Sweden

EMD centre in (name of town)	No. of inhabitants served	Size of county (Square km)	No. of employed EMD	Calls/day	Emergency calls (%)	No. of ambulances/ helicopter
Stockholm	2 milj	6 490	120	2 700-	28	57/1
Göteborg	1.6 milj	23 942	125	1 600-3 200	25	72/1
Malmö	1.2 milj	11 027	80	1 400-	29	85/0
Växjö	565 000	22 570	44	500-2 000	24	45/0
Norrköping	420 000	10 562	30	500-1 000	23	22/0
Jönköping	340 000	10 475	32	330-600	19	21/0
Eskilstuna + Gotland	314 000	9 140	33	300-900	23	16/0 1/1
Halmstad	290 000	5 454	28	250-600	25	19/0
Karlstad	290 000	6 302	30	250-500	21	25/0
Örebro	277 000	517	26	300-600	21	16/0
Falun	270 000	28 194	26	300-600	18	22/0
Västerås	260 000	6 302	29	300-400	20	13/1
Skellefteå	256 000	55 432	27	225-450	21	23/1
Luleå	252 000	98 911	28	250-400	20	28/1
Sundsvall	245 000	21 678	30	250-500	22	18/0
Östersund	128 000	49 443	32	150-300	10	13/1
Gävle	290 000	18 191	24	300-600	18	25/0
Uppsala	320 000	6 989	30	400-800	22	13/0

Protocols

Different protocols have been developed to help EMDs to assess safety, prioritise, and give pre-arrival instructions as well as advice about medical emergencies. These protocols are constructed to serve medically untutored persons. The first Medical Priority Dispatch System (MPDS) was developed in Salt Lake City in 1977 (92). Another criteria-based protocol was developed and implemented in 1990 in King County, Washington (93). The latter was further developed and implemented in Norway in 1995 (94) and became the basis for the current Swedish Medical Index which was introduced in1997. The Index, or protocol, is criteria based with 34 chapters.

It is organised in the form of a systematic survey of questions to callers. Based on the answers received, the EMDs determine the priority. For all medical complaints (i.e. allergic reactions, unconsciousness, chest pain, diabetes, seizures, stroke etc.) the protocol provides support to the EMD with medical advice and background facts. An important part of the protocol is the guidelines for telephone instructions in CPR.

The assignment of the EMD

The EMD has to identify and assess the situation by interviewing callers and if judged to be a situation where someone needs urgent help determine the level of priority and dispatch appropriate EMS unit or units as well as giving the caller pre-arrival instructions (95).

Assessment

According to the Swedish Medical Index, every answered call to 112 is to start with: What has happened? Where is the patient? From where are you calling? (telephone number, address) then as early as possible in the call determine if the patient is awake and able to talk and if the patient is breathing normally. The EMD has to get answers to these questions to assess the situation as correctly as possible and give the caller the required help, either by connecting to the appropriate authority or when it is clear that there is no emergency, inform the caller accordingly. The calls, assessments and measures cover a wide range of medical situations and place very high demands on the EMD.

If the caller uses a main line connected telephone, the telephone number and address will show automatically. Today over 60% of the calls are made by mobile phone. An increasing number of calls also come from IP telephone i.e. by a computer. In these cases the EMD cannot see the telephone number and address automatically. Much time is often lost in the procedure of establishing the correct telephone number and the location.

Prioritization

When the need for an ambulance has been established by the EMD, the urgency must be defined. This is based on the description of the event and symptoms. The system has 3 priority levels; Priority 1 for acute life-threatening conditions and accidents. Priority 2 acute but not life-threatening symptoms. Priority 3. Assignments where reasonable waiting periods are not considered to affect the patient's condition (96).

Dispatch

If the EMD suspects a life-threatening situation the ambulance dispatcher will be connected into the call while the EMD continues the communication to obtain more information and give instructions and advice depending on the situation. According to the regulations, the EMS responders are to be contacted within 90 seconds after the beginning of the alarm-call. Communication with EMS is made via a digital transmission system. When the EMS unit does acknowledges the alarm the EMD can provide additional information about the patient.

EMD life support

In the situation of a sudden CA with no one on the scene who knows how to perform CPR the EMD can make a substantial contribution as the first link between the caller, the patient and the EMS personnel.

Identification of CA

The survival in OHCA is influenced by how rapidly support is delivered. This makes the accuracy and speed of the EMD´s identification of CA crucial. The EMD identifies CA by questions to the caller about consciousness and respiration. The EMD has to be trained to differentiate between adequate and inadequate breathing, as some 40% of CA patients have inadequate breathing (agonal respiration) during the first minutes after the collapse (23). The rates of identified CA at the EMD centres vary. Hauff and colleagues described that CPR instructions were not offered in 48% of calls concerning CA in King County, Washington (28). Bång et al reported only 14% of offers of dispatcher-assisted CPR (22). More recently Berdowsky et al, found that 29% (82/285) of CA cases had not been recognized by the EMD during the call. The main reason for not recognizing CA was failure to not ask about the type of breathing (97).

Communication

The quality of the communication between the EMD and the caller is central. It is of utmost importance that the EMD is able to communicate in a professional way and independently of circumstances such as whether the caller is upset, fails to understand the questions or will not listen. The communications are also influenced by the contexts in which they occur. The work at the EMS dispatch centre is often at a high tempo and rapid rate of turn-over. There are recurrent occasions of marked emotional tension due to life threatening conditions. On the other hand, people sometimes call the emergency number without being in need of immediate care or having life threatening-symptoms (88).

Pre-arrival instructions to the caller

During the interval from the start of the call to arrival of the ambulance the EMD can give instructions to the caller on how to help the patient, until professional help arrives. This has shown to be both feasible and effective and is the standard in many EMS systems (98, 99, 100). Even if a CA situation often is very stressful, callers are often calm enough to co-operate (22). It is shown that also CPR trained people sometimes do hesitate to start CPR (101, 102) Even in such cases the EMD can probably do a substantial difference by encourage and suggest a treatment option that the caller is willing to perform i.e. chest compression-only CPR.

The education and competence of EMD

At the time of the present investigations the EMD organisation had no formal requirements of any medical training. Their knowledge and medical experience will therefore differ depending on previous experience as well as on the education provided at the EMD centre. Approximately 40% of the EMD personnel had formal qualifications as nurses, assistant nurses or paramedics. Of a total of 600 EMDs in 2006, about 20 (3%) were nurses, most of whom worked at the EMD centre in Stockholm. The number of assistant nurses was 250 (40%). Every EMD centre has physician as a medical adviser and in Stockholm this physician is present at the centre during daytime. Recently, several counties have increased their requirements in medical skills for EMDs, and all medical cases are to be handled by a nurse. The EMD are required to pass an 11-day training program in medicine, interview techniques, communication, regulations, theoretical and practical exercises. Furthermore, they are required to pass an individually based education which consists of a 40-hour, interactive web-based program in medicine and 6-month training at an EMD centre. Annually their knowledge is tested and they have to pass complimentary courses.

Rationale for this thesis

We know that bystander CPR saves lives in OHCA. Although many persons are trained in CPR, there are still too many CA victims who do not receive this early treatment. To improve the present situation ways to increase the number of patients who are given CPR in OHCA must be found. EMDs can give CPR-instructions to the bystander who calls for an ambulance, allowing even those who are inexperienced to start CPR. This thesis wants to develop this concept further by acquiring more knowledge about the role of EMDs when handling cases of suspected OHCA by exploring the circumstances involved in their identification of CA, and to evaluate if an improvement can be obtained by educational measures.

Furthermore, during the last decade chest compressions has been given a more dominant role in CPR, but still needs further investigation. This thesis will therefore also try to evaluate whether chest compression only CPR performed by bystanders who receive guiding by EMDs is as effective as or more effective than standard CPR with dispatcher assistance.

AIMS OF THE THESIS

- To describe and evaluate the frequency of offers of dispatcher-assisted CPR in OHCA, factors which can mislead the EMD in identifying such patients as well as an evaluation of callers willingness to participate in dispatcher-assisted CPR (I).

- To describe whether tuition focused on the recognition of agonal respiration will improve EMD recognition of CA and subsequent assisted CPR by telephone (II).

- To compare 1-month survival among OHCA patients who have received bystander CPR by mouth-to-mouth ventilation and chest compressions with those given chest compressions only before EMS arrival (III).

- To explore whether dispatcher-assisted chest compressions-only CPR improves CA survival compared with dispatcher-assisted standard CPR (IV).

MATERIAL AND METHODS

The papers included in this thesis are based on four study projects. Paper I and II use an exploratory and descriptive design. Paper III is based on the Swedish Cardiac Arrest Register and is descriptive. Paper IV is a prospective, randomized investigation.

Papers I and II

Patients and design

Paper I deals with 315 consecutive cases of OHCA collected during 20th January to 3rd May in 2004. Those cases who met the inclusion and exclusion criteria as witnessed, non-traumatic CA were included.

Paper II deals with 255 consecutive cases of OHCA collected during 1st June to 20th August in 2006. In cases who met the inclusion and exclusion criteria as witnessed, non-traumatic CA and the corresponding tape recording of the emergency call were analyzed by the present author. A specialised nurse at the EMD centre together with the author listened to and evaluated the first 20 taped recordings, to reach consensus on how to assess the information about respiration. The analysis of the tape recordings from study I was used as a historical control group. The special tuition about agonal respiration was held by a physician and a nurse who is responsible for education at the EMD centre. It was offered as a 1-day course at three different occasions. The tuition included air-way anatomy and physiology relevant to CA. The EMDs also listened to authentic recorded conversations presenting various expressions used by callers when describing threatened vital parameters as well as ten authentic recorded conversations concerning CA in which various breathing sounds and forms of breathing were described. Over 90% of the EMDs attended the tuition.

Cases of witnessed OHCA of presumed cardiac origin and in whom the CA occurred before EMS arrival were included in these investigations. If CPR was considered not to be meaningful or if CPR was already ongoing, the case was excluded as were all victims under 9 years of age.

All emergency calls are recorded and saved for three months. To identify recorded OHCA calls, we used the National Swedish Cardiac Arrest Register which comprises all cases of CA reported by ambulance personnel. The tapes were assessed according to various predetermined aspects regarding consciousness, respiration and EMD offers of T-CPR. A similar form has previously been used by others (22). In addition the information from tape recordings, ambulance reports were reviewed to determine patient demographic characteristics (i.e. age and sex), event circumstances such as presence of witnesses before EMS arrival, place of arrest and presenting rhythm (II), bystander characteristics (relationship to the victim if any) and survival to day 30.

The definition of agonal respiration used was: Caller description of a person with breathing that is not normal in combination of unconsciousness.

Paper III

Register

This study is based on a patient material from the Swedish Cardiac Arrest Register, which is a joint venture of the Federation of Leaders in Swedish Ambulance and Emergency Services (FLISA) and the Swedish Council for Cardiopulmonary Resuscitation. The register has been funded by the Swedish National Board of Health and Welfare since 1993. It was started in 1990 and covers about 70 % of the population in Sweden (total population 9 million). Larger cities (all major cities) as well as sparsely populated areas are represented in the register that also has a geographical distribution covering most of Sweden. The ambulance organizations not reporting to the register are not different in terms of education, training of staff or guideline used.

Patients

Our inclusion criteria were patients who suffered an OHCA and who received any form of bystander CPR and who were reported to the Swedish Cardiac Arrest Register between 1990 and 2005. Crew witnessed (ambulance staff, police, health care provider) cases of OHCA were excluded. Totally 11 275 patients were included, 8 209 patients having received standard CPR and 1 145 patients who received chest compression only, before EMS arrival. This study only includes patients in which the EMS started resuscitation.

Study design

For each case of OHCA the ambulance crew completed a form to register demographic information and whether the collapse had been witnessed (seen or heard). The form also included questions regarding the resuscitation procedure and other interventions, as well as information regarding the rescuer (layman, ambulance crew or others). The first recorded rhythm was classified as VF, pulseless electrical activity or asystole. Rhythm detection by the rescue team was obtained using a manual defibrillator. When automated external defibrillators came into use, the rhythm was defined as shockable, or nonshockable. For the purposes of this survey, VF as well as pulseless ventricular tachycardia were registered as VF. The form was completed during and immediately after the acute event. Each form was sent to the medical director at each ambulance district and a copy was sent to the Swedish cardiac arrest register. Another copy was subsequently sent to the same register with additional information about whether the patient was dead or alive after 1 month. Incomplete information about survival was controlled by checking with the National Register of Deaths.

Paper IV

Paper IV is based on the TANGO study and has a prospective, randomized design.

EMS organisation

The Swedish dispatch organisation receives all 112 emergency telephone calls. Every day, 18 geographically well-spread emergency medical communication centers (EMCC) respond to about 10,000 calls from around the country which has 9 million inhabitants. Two centers did not participate in this investigation as they were involved in other studies. The EMCC´s serves urban as well as rural areas. The ambulance organization in Sweden works according to a two-tier system. For each call judged to be a CA two ambulances, staffed with a nurse, are dispatched. In some sparsely populated areas only one ambulance is dispatched. All emergency units are equipped with a defibrillator.

The EMCC organization employs about 600 emergency medical dispatchers. To qualify as a dispatcher 6 months of dispatch training is required. This formation includes interview technique training, computer training, 2 weeks of basic medical training, one to two revision courses on basic CPR training and a 2-day course on how to deliver instructions by telephone to assist bystanders in performing CPR. Each dispatcher handles approximately 30-40 calls concerning OHCA per annum at the larger EMCCs (serving 1-2 million inhabitants). The corresponding figure for smaller EMCCs (serving about 175-250 000 inhabitants) is about 8 calls.

Patients and design

According to the criteria based protocol the dispatcher should suspect CA in case of a call about a patient who is unresponsive and not breathing or not breathing normally. Because of the present study the dispatcher then tries to determine if the collapse was witnessed (i.e. seen or heard) which was an inclusion criterion and if there were any exclusion criteria present, i.e CA caused by trauma, respiratory arrest (e.g. drowning, choking), intoxication and age under 9 years. Furthermore, if no one at the scene had started CPR and the caller was willing to be instructed about this form of help, the EMD was to give instructions to the caller in either standard CPR (mouth-to-mouth ventilation *with* chest compressions, 2:15) or chest compression only CPR, randomly determined by removal of a paper strip on a randomization sheet. Treatment was thus blinded to the dispatcher before randomization.

On the randomization sheet the dispatcher entered information about inclusion and exclusion criteria and, after the call, whether CPR instruction was given, and what type of instructions had been given (standard CPR or chest compression only CPR regardless of randomisation). The dispatcher also had to describe to what extent the instruction was given (i.e. until EMS arrived or interrupted before EMS arrival). Data were collected and entered in a database for all included episodes. Data was also collected from EMS records. Information concerning co-morbidity and survival status was collected from national registers. The primary end point was survival to day 30, the secondary end point was survival to arrival at hospital defined as survived day one.

Statistics

Power analysis

The power calculation in *paper II* was based on the data from our first study in 2004. It was realistic to evaluate about 80 patients, the same sample size as in 2004. Then there was an 80% chance to discover a true difference given that the offers of T-CPR increased from 50% in 2004 to 75% in 2006.

In *paper IV* originally, a sample size estimate of 2 213 patients in each study group provided an 80% power to detect a two percentage point improvement in survival rate on day 30 (from 5% to 7%) in the EMD compression-only CPR group versus standard CPR with a 2-sided alfa=0.05.
Because CPR-guidelines were changed during the study and gave compression-only CPR a more dominant role (Handley et al resuscitation 2005), and due to practical

reasons to run a study for more than four years approximately 1 000 patients in each group was the largest number that could be realistically to include in the study. This revised sample size was estimated to provide 78% power to detect a three percentage point difference (from 5% to 8%), which was considered sufficient to continue the study. The calculations were performed in Sample Power 2.0.

Statistical analysis
The statistical software used was SPSS 15.0 (studies I and II), SPSS 16.0 (study II), SAS system for Windows v 8 (study III) and PASW 18.0 (study IV) (SPSS Inc., Chicago, Illinois)

In study I and II descriptive statistics were used to evaluate the data, including frequency and percentage (I,II), and means and standard deviation (SD) for the categorical variable (II). Fisher´s exact test was used for non-parametric comparisons. Two-tail test was applied when testing for breathing.

In study III distribution for the variables was given as mean and SD, medians (quartile 1 and quartile 3) and percentage. For comparison between groups regarding ordered and continuous variables Fisher's non parametric permutation test was used. For comparison of dichotomous variables between groups Fisher's exact test was used. Logistic regression was used to adjust for variables that were significantly different in the two the groups. Odds ratios (OR) were calculated with 95% confidence interval (CI).

In *study IV* data were analyzed both according to the patients randomized treatment assignments (intention-to-treat) as well as on those who actually received the treatment (per-protocol). As the results were similar we only present the results from the former. No imputation was used for missing data. The Chi-square test was used to compare the two treatment groups. The 95% CI for the difference between the rates was based on the normal approximation. A logistic regression model was used to adjust for possible confounders. Outcome factor was survival at day 30 (yes/no) and the model strategy was as follows; First, the unadjusted association between survival and type of CPR instructions was estimated. Second, to study the impact of each of the possible confounders, we added each of the baseline characteristics one at a time together, with type of CPR in a multivariable model. Finally, we added all the factors and compared the crude and adjusted association to evaluate if the possible confounders had any impact on the association between survival and type of CPR. The associations are presented as odds ratios (OR) with 95%
CIs.
The results, in all four studies, were considered as significant if *p*-value was less than 0.05, two tailed.

Ethical considerations
Approval by the Ethics Committee, Karolinska Institutet, Stockholm was obtained for study I, II and IV. The Ethics Committee at the University of Göteborg approved the protocol for study III.

Informed consent was obviously not obtained from patients nor callers in study IV. The reasons for this, which were accepted by the Ethics Committee, are that in CA all time is very expensive and we believe that an explanation of the two experimental arms would take too long.

Criticism could be raised that the patients were not the only study subjects, but also the involved EMS dispatchers. The dispatchers' performance in handling study related issues during the call was measured (I,II).

SUMMARY OF RESULTS

Paper I
Dispatcher-assisted telephone-guided cardiopulmonary resuscitation - an underused lifesaving system.

To describe how often dispatcher-assisted CPR is offered and those factors which could mislead the EMD in identifying the patient as a CA victim as well as callers willingness to participate in dispatcher-assisted CPR 313 emergency cases of OHCA were included during January 20 to May 3, 2004. The dispatchers complied with the initial page in the Medical Index Protocol in more than 90% of the cases. The vast majority of callers were judged to be sufficiently emotionally stable and capable of cooperating with the EMS dispatcher.

In 38% (n=76) of all OHCA cases where CPR treatment started (n=200) during the study period, telephone assisted CPR was a treatment option. The most common reasons for exclusion were unwitnessed CA and obviously deceased patients patients. The mean age of the patients was 73 years (range 26-98). Fifty five percent were men. As shown in table 2, most witnesses were family members and most CA occurred in the victims' homes. Among the 76 cases which met the inclusion and exclusion criteria, telephone CPR guidance was offered in 36 (47%). Figure 1. It was accepted and T-CPR was performed in 25 (33 %) cases. Only two bystanders refused to participate.

Table 2. Callers background characteristics (n=76)

	n	%
Callers identity		
Spouse/relative/friend	49	64
Stranger	10	13
Health care providers	13	17
Patient him/herself	1	<1
Callers gender		
Male	34	45
Female	40	53
Place of arrest		
Home	61	80
Other places	15	20
Time of arrest		
Day 07.00-21.59	64	81
Night 22.00-06-59	11	18

A description of breathing was available in 69 of the 76 cases. In 44 (64%) of 69 cases the caller reported that the patient was breathing, which in 34 was described not to be normal. The remaining 25 (36 %) cases were classified as not breathing. Dispatcher assistance for CPR was offered for 23 % (n=10) of patients described to be breathing versus 92 % (n=23) of patients who were not breathing ($p<0.001$).

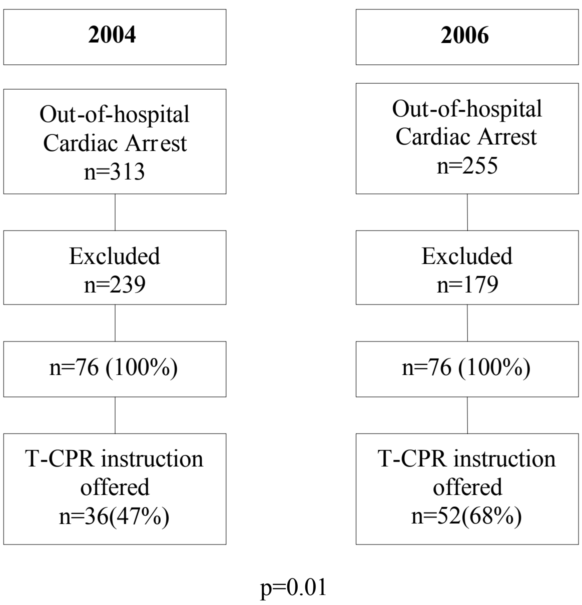
Paper II

Tuition of emergency medical dispatchers in the recognition of agonal respiration increases the use of telephone assisted CPR

This study describes whether tuition regarding the recognition of agonal respiration improves the ability of EMDs to recognize CA and subsequently offer T-CPR.

In all, 313 OHCA cases were reviewed from 2004 (before intervention) and 255 from 2006 (after intervention). The most common reasons for exclusion were unwitnessed CA and obviously deceased patients patients. Set criteria were fulfilled by 76 cases of OHCA in both groups (Figure 3) and the corresponding audio recordings were reviewed. There was a high willingness to cooperate among the bystanders, 97 % in 2004 and 100 % in 2006 received CPR instructions.

Figure 3. Study population before (2004) and after (2006) special tuition in agonal respiration for emergency medical dispatchers.



The age and gender distribution of the two groups was similar. Most witnesses were family members and most CA occurred in the victims' homes. About 20% had VF as the first recorded rhythm in both groups. CA occurred most frequently during the day time.A description of respiration was available in 69 (91%) calls 2004 and 62 (82%) calls 2006. Expressions like wheezing, snoring, snuffling, hard breading, labored breading, difficult and heavy breading, bad breading, occasional, poor and irregular breading, were the most common description by the callers. In 2004 44 (64%) callers described that the patient was breathing or had an abnormal breathing (agonal respiration). The corresponding figures 2006 were 39 (63%).
The EMDs complied with the protocol (as regards asking if the patient was awake and breathing normally) in more than 96% of cases in 2004 and in 99% in 2006.

T-CPR was offered in 47% (n=36) of cases before tuition, compared to 68% (n=52) after (p=0.01) Figure 3. An increase was also seen, after tuition, in victims with agonal respiration, 23% had been offered T-CPR in 2004 whereas. 56% were offered T-CPR in 2006 (p=0.006), Figure 4. T-CPR were accepted and completed in 25 (33%) calls in 2004 and in 36 (47%) calls in 2006. The 30-day survival was 3% in 2004 and 7% in 2006 (p=0.27).

Figure 4. Frequency of offered T-CPR in relation to agonal respiration, before and after tuition in agonal respiration for Emergency Medical Dispatchers. n(%)

Year	**2004**	**2006**
No.of patients	76	76
Description of breathing given by caller	69 ↓	62 ↓
Agonal respiration described	44 ↓	39 ↓
T-CPR offered	10(23%)	22(56%)

p=0.006

Paper III
Survival is similar after standard CPR and compression-only CPR in out-of-hospital bystander cardiopulmonary resuscitation.

To compare the 1-month survival among OHCA patients who received bystander CPR in form of mouth-to-mouth ventilation *with* chest compressions (standard CPR) with those given compression-only CPR before the arrival of EMS, 12 740 patients in 1990-2005, were included in the survey.

Information as to type of CPR that had been given was missing in 1465 patients (11%). Among the remaining 11 275 patients, 8209 (73%) received standard CPR whereas 1145 patients (10%) only received compressions only. For unknown reasons, 1921 patients (17%) had received only mouth-to-mouth CPR.

Patients who were given compressions only were older, less likely to be found with VF and the interval between the call for and the arrival of the ambulance was shorter. Patients who received standard CPR had significantly more often been given CPR by health care providers than patients who received compressions only (Table 3).

Table 3. Characteristics of patients who received standard CPR compared with compression-only CPR

	Standard CPR n=8209	**Compression-only CPR n=1145**	**p**
AGE mean + SD years	63+18	66+16	<0.0001
SEX woman %	25	23	0.045
Bystander witnessed %	74	73	NS
Place at home %	49	52	0.076
Aetiology cardiac %	70	71	NS
Initial rhythm ventricular fib	40	36	0.012
Delay from call for to arrival of ambulance median	8	6	<0.0001
(Q1-Q3) minutes	5-13	4-10	
Type of bystander. %			
Layperson	51	67	
Ambulance staff	3	1	
Police	2	2	
Health care provider	32	20	
Other	16	11	

There was missing information concerning bystander witnessed, aetiology, initial rhythm and type of bystander in up to 10% of patients. For the other variables there was missing information in up to 5% of patients.

There was, however, no significant difference between patients who received compressions only and standard CPR in terms of being hospitalized alive or being alive after 1 month. When adjusting for differences at baseline (age, sex, time and type of bystander) the adjusted odds ratio for survival to 1 month (standard CPR versus compressions only) was 1.18 (95% confidence interval 0.89 – 1.56), as shown in Table 4.

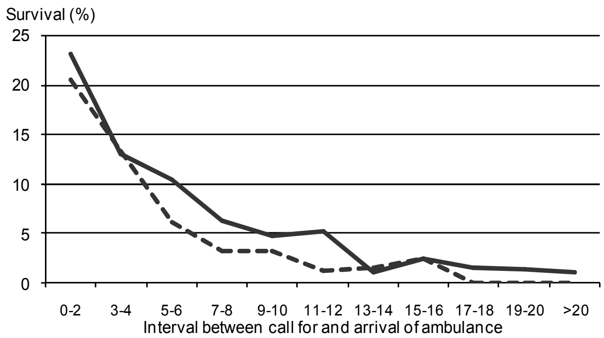
Table 4. Survival of patients who received standard bystander CPR compared with Compression-only CPR

	Standard CPR	Compression-only CPR	OddsRatio
Hospitalized alive%	19.6	20	
Adjusted			1.03(0.86-1.23)
Unadjusted			0.97(0.85-1.13)
Alive at one month%	7.2	6.7	
Adjusted			1.18(0.89-1.56)
Unadjusted			1.10(0.86-1.40)

(95% confidence interval. Adjusted for: age, sex, ambulance response time, type of bystander.)

When relating survival to ambulance response time there was no significant difference between standard CPR and compressions only in survival to 1 month neither when delay was short (≤ 8 min; 11.5% versus 9.5%; NS) nor when delay was long(> 8 min; 2.7% versus 1.8%; NS). The relationship between ambulance response time and survival in the two groups is illustrated in detail in Figure 5.

Figure 5. **Percent survival for Standard CPR and Compression CPR in relation to ambulance response time.**



Patients who received mouth-to-mouth ventilation only were somewhat younger, were more often women, considerably more frequently suffered from OHCA at home, were less likely to have a cardiac aetiology and were less frequently found in VF. They had a shorter delay time between call for and arrival of ambulance than patients who received standard CPR.
Furthermore, fewer patients who received mouth-to-mouth ventilation were hospitalized alive and a lower proportion of patients was alive after 1 month as compared with patients who received standard CPR (4.5% $p<0.0001$ versus standard CPR).

Paper IV

Dispatcher-assisted instructions for compression only CPR compared to standard CPR in witnessed out-of-hospital cardiac arrest.

This paper explores whether dispatcher-assisted compression CPR improves CA survival compared to dispatcher-assisted standard CPR with compression and ventilation. A multicenter, prospective, randomized trial. The primary end-point was 30 day survival.

Enrolment started February 2005 and was terminated January 2009 at which time there had been 3809 randomized episodes of suspected OHCA and of these, 49 % (1867 patients) were excluded because of reasons reported in table 5 and figure 6.

Figure 6. Flowchart for randomized cases.

Randomized
N=3809

Excluded n= 1867
Not meeting inc criteria n=792
Exclusion criteria n=323
Other exclusion n=443
Missing n=309

Allocated to
Standard CPR
n=974

Lost to follow-up
n=55

Analyzed (Intention-to-treat) (n=656)
Excluded from analysis (n= 263)
Give reasons: Not resuscitated by EMS

Analyzed (Per protocol) (n= 575)
Excluded from analysis (n=81)
Give reasons: Did not receive the allocated treatment (n= 29)
Allocated CPR instruction started but stopped before EMS arrival* (n= 52)

Allocated to
compression-only CPR
n=968

Lost to follow-up
n=67

Analyzed (Intention-to-treat) (n=620)
Excluded from analysis (n= 281)
Give reasons: Not resuscitated by EMS

Analyzed (Per protocol) (n=461)
Excluded from analysis (n=159)
Give reasons: Did not receive the allocated treatment (n= 98)
Allocated CPR instruction started but stopped before EMS arrival* (n= 61)

*Reasons for interrupted CPR instruction: The caller performed CPR without instructions, communication problems, the caller was not able to do CPR, signs of life were seen, EMS arrived, the caller did not want to do CPR.

To select cases of true CA, patients who did not receive CPR treatment by the EMS personnel after their arrival were excluded. Furthermore, 266/3809 cases were lost to follow up. The number of cases available for the final analysis was 1 276. Of the remaining 1276 patients randomly assigned to treatment and included in the intention-to-treat analysis 51 % (656/1276 patients) were assigned to instructions for standard CPR and 49 % (620/1276 patients) were assigned to compression-only CPR. Of the 1276 randomised intention-to-treat patients 81% (1036 patients) were treated per-protocol. As seen in figure 6, 9 % (127/1276 patients) did not receive the treatment in which they had been allocated. In 7% (98/1276 patients) assigned to compression-only CPR the dispatchers incorrectly gave standard CPR instruction, mainly out of habit or that the dispatcher thought that the patient fulfilled an exclusion criterion during the call.

Table 5. Inclusion- Exclusion criteria. N= 1867

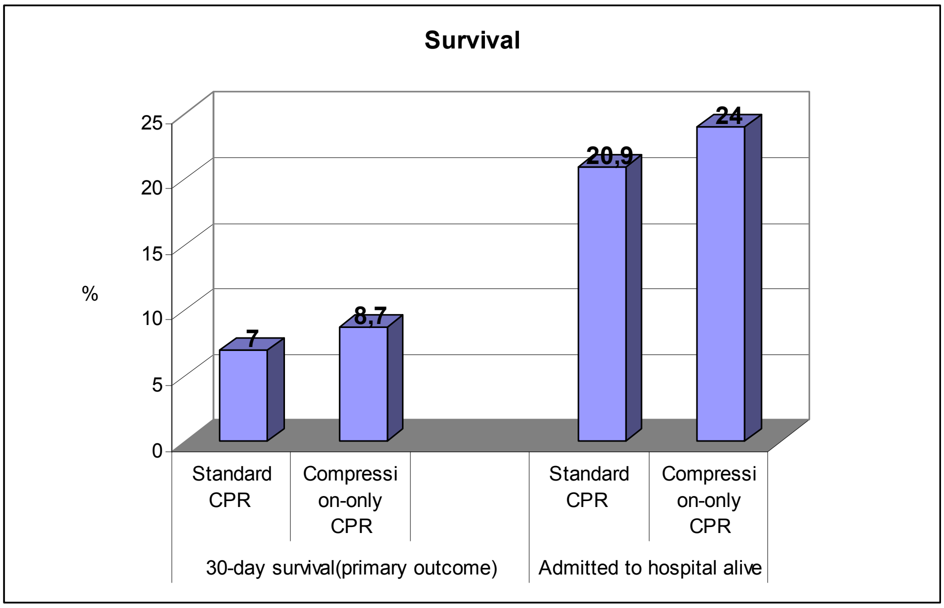
	Standard CPR	Compression-only CPR
	n	%
Inclusion criteria not fulfilled		
Unconscious Not breathing/normal Witnessed cardiac arrest	792	42.4
Exclusion criteria		
≤ 8 years	18	0.9
Airway obstruction (drowning, hanging)	45	2.4
Intoxication	155	8.3
Trauma	61	3.2
Other reasons for exclusion		
EMS arrived	17	0.9
Signs of life	90	4.8
Communication problems	39	2.0
CPR ongoing/ Know how to do CPR	54	2.8
Obvious signs of death	22	1.1
The caller not able to	123	6.5
The caller not willing to	88	4.7
Unknown	10	0.5

More than one criterion could be entered

Cardiac arrest episodes and patient demographics were similar in the two treatment groups. The time from call to arrival of EMS averaged 10 minutes.

The 30-day survival rate in the standard CPR-group was 7.0 % (46 patients) and 8.7 % (54 patients) in the group receiving compression-only CPR. (1.7 percentage points difference, 95% CI -1.2-4.6, p=0.29). Admitted to hospital alive was seen in 20.9 % in the standard CPR-group and in 24 % in the compression-only CPR-group. When adjusting for characteristics of the episodes, a logistic regression analysis did not substantially change the results in neither of the analysis. In 6.9 % (266/3 810 patients) of the study population patients were lost to follow-up. The main reason for this was that the corresponding EMS field reports could not be found. This was mainly seen in a small number of EMS districts. We therefore performed a sub analysis, excluding districts with more than 18% of the patients lost to follow-up. No substantial difference from the main results was found.

Figure 7. Primary and secondary outcomes for dispatcher-assisted Standard CPR and Compression-only CPR in witnessed out-of-hospital cardiac arrest.



DISCUSSION

Paper I and II

To find all true CA cases, during the study period a consecutive and prospective data collection was made with the help of the Swedish Cardiac Arrest Register. Its data are based on the observations and registrations made by ambulance crews. One purpose of paper I and II was to select calls in which the dialogue was meaningful for the identification process of CA. In order to obtain a group as homogeneous as possible a target group of witnessed and non-traumatic OHCA in adults was chosen. For practical reasons the collection of consecutive OHCA cases was restricted to a period of 3.5 months which resulted in the present sample size of 315 patients in study I. A power calculation for study II revealed that a similar sample size was needed to test the intended hypothesis. A prospectively planned study with historical controls does not have the statistical strength of randomized studies, but all measures were taken to have the two patient groups as similar as possible. No EMD was informed about the studies during data collection as awareness of being watched may by itself affect the quality (103). However, other factors, such as performing study IV during the same time period, may have influenced the outcome, even though not specifically addressing agonal respiration.

Is the presently used definition of agonal respiration optimal for the identification of CA by EMDs?

The data in study I and II relies on descriptions of a critical medical phenomenon made by lay people, who have no reference point for describing it. The definition of agonal respiration used in our studies; “any description of abnormal respiratory efforts in combination of unresponsiveness” is used also by others (22, 104,105). There is no perfect medical definition for agonal respiration. According to Stedman´s Medical Dictionary the term agonal is related to the process of dying or the movements of death (106). The ERC guidelines have adopted a pragmatic attitude and state that laypeople should begin CPR if the victim is unconscious and not breathing normally (6). The potential risks of such definitions may be that EMDs overestimate some cases as CA. This is illustrated by agonal respiration which also may be a result of an airway obstruction (107).

Checking the carotid pulse by lay people is an inaccurate method of confirming the presence or absence of circulation (108). This favours the description of “abnormal respiratory efforts in combination of unresponsiveness” as the best to identify CA by EMDs.

How often does agonal respiration occur in OHCA?

The true incidence of agonal respiration after CA is unknown. In the present studies the incidence of agonal respiration was estimated to about 60%. Others have shown that agonal respiration was present in 30% of all-cause CA (22). Bobrow et al reported agonal respiration in 33% of patients in whom resuscitation was attempted by the EMS. Agonal respiration was present in 33% of cases with CA after EMS arrival and in 20% when EMS arrival was delayed by <7 minutes, 14% when 7 - 9 minutes, and 7% when EMS arrival was delayed by >9 minutes (23). Clark et al reported that 55% of witnessed cases and 20% of unwitnessed cases had agonal respiration. In cases with a cardiac aetiology agonal respiration was seen in 46%, and in 56% of patients with VF (21). As our target group was witnessed CA of presumed cardiac origin the incidence of about 60% seems reasonable.

How can recognition of CA be improved?
Additional education of EMDs to improve recognition of CA with focus on agonal respiration has been proposed (20, 100, 109). The present study (II) showed that a brief tuition in recognising abnormal breathing as a sign of CA led to a significantly higher frequency of offered CPR instructions by EMDs. This is in line with Perkins et al who in a simulation study improved the diagnostic accuracy among CPR providers after specific tuition in agonal respiration as a sign of CA (110). In study II an increase of identified CA was seen after the tuition it is, however, not clear if the proportion of overestimation of CA also was increased because only true CA cases were investigated.

The interrogation by the EMD is very important for the judgment of an emergency call. If accuracy is high, fewer cases will be mistakenly assessed as CA and a higher percentage of true CA will be detected. Feedback from the EMS personnel to the EMD is an interesting possibility to increase the proportion of correctly identified CA. An evaluation of the emergency call can be made in each case if the EMD has access to the EMS personnel's initial assessment on the scene. This system also allows for regular assessments of emergency calls in a systematic manner. Such feedback project is presently ongoing (111).

Paper III
Studies based on registers have a number of limitations such as lack of information on certain variables, selection bias, recall and input error. Furthermore, the information about OHCA is usually compiled under stressful situations and this will affect reliability. Careful instructions on how data collection is to be made in the annual report lend some support to those reporting data. One strength with register studies is that they allow for investigations of large samples.

A major problem is how to deal with confounding factors in observational studies. Adjustments were made for several confounding factors but one can not exclude the presence of other such factors. Comorbidity is one of these factors for which there are no data in the Cardiac Arrest Register. Due to the publication of new international guidelines during this study different compression ventilation ratios were used and we cannot rule out the possibility that this has influenced the results.

Which circumstances may have affected the outcome?
Women and younger persons are reported to have better prognosis in OHCA (112, 113) but none of these two factors affected the survival rate in our study population. The ambulance response time, from call to arrival of ambulance, was significantly shorter (6 vs 8 minutes) in the compression-only CPR group which may have influenced the outcome in a favourable direction for this group (33). However, when adjustments were made for this difference, the overall result did not change. VF is one of the strongest predictors of survival in OHCA as has been demonstrated repeatedly (32, 33, 34). Since VF can be regarded as an effect variable, adjustment was not made for initial rhythm.

VF was more frequent encountered in the standard CPR group than in the compression-only group which probably affected the outcome favourably in the standard CPR group.

The reasons for which some patients received standard CPR and others compression-only CPR in study III are unknown. Our investigation covers a time when only standard CPR was taught and recommended. Standard CPR was more often performed by health care providers, as has also been reported by others (34a). This is of importance and may have affected the results in a positive way in the standard CPR group as CPR performed by laymen has been shown to be less effective and VF as initial rhythm is less common than in patients handled by professionals (34a, 65). One can only speculate on why laypersons more often performed compression-only CPR, but a greater reluctance to perform mouth-to-mouth ventilation may be one reason (79, 80). Furthermore, the relatively high survival rate in the compression-only group can most probably be explained by the predominant importance of rapidly starting and continuously performing chest compressions which is in agreement with the CPR guidelines from 2005 (6, 72, 114, 115).

How do our results compare with other studies?
Three non-randomized observational studies of OHCA addressing the efficacy of standard CPR versus compression-only CPR were published in 2007 of which the present investigation was one (75, 76). None of these demonstrated any negative impact on survival when mouth-to-mouth ventilations were omitted. In the other two studies only witnessed OHCA cases were included. In the investigation by the SOS-KANTO study group bystander compression-only CPR showed a better neurological outcome than bystander standard CPR in CA of all causes. However, those results only applied to some sub-groups (patients with apnoea, shockable rhythm and resuscitation started < 4 minutes) (75). Iwami et al reported no difference in 1-year neurologically intact survival between victims of OHCA of presumed cardiac origin who received bystander compression-only and those who received standard CPR (76).

Paper IV
This investigation wanted to establish a cause-effect relationship and a randomized strategy was therefore used in which patients randomly were assigned to either intervention or control groups. Many of the randomized patients were, however, excluded from the analysis as they failed to meet predefined inclusion and exclusion criteria. For evident reasons it was not appropriate to squander time in screening for all criteria before starting CPR instructions. The result was that we could not strictly follow an intention-to-treat approach which is a limitation. Expectations of effect can influence investigators, and blinding is therefore used to eliminate such bias. In the present study the treatment to be given was covered under a paper strip, and was thus blinded to the dispatcher before randomization. A number of the dispatchers did not follow the randomized instructions. The reason for this protocol violation is most probably that dispatchers had prejudices against the compression-only technique and therefore preferred standard CPR, especially in the beginning of the study. Furthermore, in a number of cases the bystander wanted to perform the other CPR technique rather than the technique obtained by randomization.

During the intervention period CPR international guidelines were changed from the ratio 2:15 to 30:2. These guidelines had not yet been implemented as they appeared in our national guidelines only as late as in January 2007, two years after the initiation of our study. Furthermore, these new international guidelines do not include dispatcher CPR (6).

Do EMDs misjudge OHCA?

In the study by Hallstrom et al, 20% (270/1296) of the cases were mistakenly identified as CA, however, of which only 3% (7 patients) actually received dispatcher-assisted CPR (7). Most of the mistakenly identified cases had conditions which also may present with unresponsiveness and abnormal respiration (syncope, seizure, intoxication and stroke) and differentiation from suspected CA may indeed have been difficult. Syncope, however, is a condition with return of consciousness within a short period of time and the EMD should be able to detect these situations during the call. In the investigations by Bång et al the EMDs frequently reported lack of information as a reason for misdiagnoses (116) as well as failure in the interview of the caller (22).

In a study from Seattle, for every 6 correctly identified CA, the EMD identified 1 non-CA as CA and offered T-CPR instructions which were accepted in 68% of the cases. Instructions were completed for one-third (71/190) of the non-CAs in which the offer was accepted. No serious adverse events were described on the EMS reports due to CPR and adverse sequelae were described among the 14 non-CA who received T-CPR (117).

Can CPR in private locations be improved?

The chances of survival after CA in private locations are therefore low, about 2% (40). Bystander CPR is much less common in patients collapsing at home even when witnessed. Reasons for this are probably that bystanders at home are older, less frequently and less recently trained in CPR, and less ready to perform CPR even when trained. (68). Only one in four patients who suffer a CA at home received CPR compared with one in two who suffer the arrest outside their homes as shown in the Swedish Cardiac Arrest Register (40, 65). A better access to bystander CPR is accordingly much needed in cases of CA in the homes of patients, especially as citizen training programs mostly reach a younger population (69, 118).

What do we know about the quality of bystander CPR when guided by EMDs?

No assessments of the quality of bystander CPR are available in the present studies. However, the findings by Rea and colleagues suggest that the quality of dispatcher-assisted CPR is comparable with bystander CPR without such assistance (100). A simulation study showed that volunteers without prior CPR training who receive dispatcher instruction demonstrate similar CPR skills compared to previously trained persons performing CPR without instructions. More time had, however, elapsed between collapse and initiation of CPR in the dispatcher group (119). In the study by Dorph et al, none of the test subjects performed chest compressions of adequate quality (120). A possible reason for this could be that they studied different groups, Kellerman et al reported results from a much younger group, the average participant was 39 years old (119) whereas the average participant in Dorph´s study was 78 years old (120). CPR performance is indeed a physically demanding task and may be beyond the abilities that can be expected from older bystanders. However, Wollard et al reported very poor performances even in a much younger group (median 30 years) of volunteers receiving dispatcher guidance for either standard or compression-only CPR (121).

Is survival improved by dispatcher-assisted CPR by telephone (T-CPR)?
Rea et al reported that dispatcher-assisted bystander CPR increased the odds of survival compared with no bystander CPR. Among those who suffered a witnessed arrest the survival advantage for the dispatcher-assisted CPR group increased with longer EMS response times (100). Others have reported similar survival rates among CA patients receiving either dispatcher-assisted bystander CPR (21%) or bystander CPR without dispatcher assistance (24%), whereas no bystander CPR, while waiting for the EMS, resulted in a 13% survival (122). A survival benefit associated with dispatcher-assisted CPR when compared to no bystander CPR before the EMS arrived, mostly because the shortened interval from collapse to start of CPR (50, 123).

How much time do dispatcher-assisted CPR instructions by telephone require?
In a simulation study, the time required to deliver standard CPR instructions (from the time of call to start of chest compressions) by telephone was about 4 minutes for previously untrained volunteers compared to 1.2 minutes for previously trained volunteers without dispatcher assistance (119). Others have reported that in the field it requires 2.4 minutes (mean) to deliver complete CPR instructions by telephone (122). Rea et al found that mean time from collapse to CPR was approximately 1 minute longer for T-CPR than CPR without dispatcher assistance (100). Other workers have found that if CA was recognized by the EMD, the EMS would arrive 1.40 minutes earlier on scene (97). By giving dispatcher-assisted CPR according to a more simplified protocol with chest compressions only, it is likely that the telephone instructions will be less time-consuming (124).

What is the benefit of compression-only dispatcher-assisted CPR?
Results from two CA simulation studies have revealed that airway opening was poor and rescue breathing inadequate, which implies that a simplified T-CPR protocol without ventilation instructions will make a little practical difference (120, 121). By eliminating the ventilation instructions, the delay to chest compressions decreased by 1.5 minutes (120). This is in line with Wollard et al and Hallstrom et al who reported decreases of 1 and 1.4 minutes, respectively (7, 121). Furthermore, differences have been described in the number of compressions given with compression-only T-CPR; Wollard et al showed that almost 2 ½ times more chest compressions were performed with chest compressions only (121). Others have found both greater numbers of chest compressions performed per minute as well as longer compression periods (83, 125-127).

Are bystanders willing to start CPR? If not, why?
The most common reasons for trained bystanders not to perform CPR are that they panick and fear that they are unable to perform CPR correctly, whereas only a minority objects to perform mouth-to-mouth ventilation (101, 102). Further work is clearly needed to ensure better confidence in performing CPR after CPR training. The dispatcher has an important role also in these situations. A combination of prior CPR training plus the encouragement by the dispatcher-assistance is suggested to be most

successful (116).

Furthermore, both laymen as well as health care providers are more willing to perform compression-only than standard CPR. Among laymen the main reason is doubt concerning their ability to effectively perform CPR, whereas health care providers fear that they may catch a disease (128). Others report that a minority of laymen as well as of health care providers would definitely initiate CPR on a stranger if only chest compressions were required (129).

What is the rationale of the compression-only strategy?
Animal studies have shown that coronary perfusion pressure gradually builds up during the first few chest compressions (74, 130). Longer and uninterrupted sequences are therefore better for the circulation. Investigators have also pointed to an association between coronary perfusion pressure and return of spontaneous circulation (ROSC) in humans. In patients who achieved ROSC, the pressure gradient from the central aorta to the right atrium was 13.4 mmHg compared with 1.6 mmHg in those not achieving ROSC (131). In a VF rat model the relationship between coronary perfusion pressure and chest compressions was exposed. The aortic pressure was 26 mmHg during uninterrupted chest compressions and all animals achieved ROSC following defibrillation. After only 10 seconds interrupted ventilations the aortic pressure fell to 6 mmHg and the ROSC rate was reduced to 60% (132). Others found that ROSC could be predicted by the VF waveform by analysing sequences of electrocardiogram downloads from AEDs (133). They also showed that only 20 seconds of "hand off" time decreased the predictive success rate substantially (134). In conclusion, both coronary perfusion pressure and VF waveform can be maintained by chest compressions and both deteriorate rapidly when compressions are interrupted.

Cardiac versus respiratory arrest
The analyses and conclusions in the present study do not adresses unwitnessed CAs as well as CA due to primary respiratory failure. Even if CA due to respiratory failure is much less common than CA due to cardiac causes, several circumstances can cause respiratory arrest. In a case of respiratory arrest, the establishment of a patent airway and rescue breathing can maintain oxygenation and prevent a CA (11). However, the survival to discharge from hospital in patients following drug overdose, alcohol intoxication and carbon monoxide poisoning was similar in dispatcher-assisted compression-only CPR cases and those given standard CPR in the study by Hallstrom et al (7). In the present study a considerable number of cases with intoxications were initially included. It remains to be shown whether EMDs may be able to distinguish which cases require instructions for standard CPR rather than compressions only.

Future improvements?
To save a larger number of patients with OHCA further efforts are required to increase the number of CA victims who receive effective CPR. Developments are needed to increase both speed and accuracy of EMDs identification in CA.

The instructions to the caller on how to perform CPR are also important to improve. Does the caller understand the instructions? How does the communication work between the EMD and the caller? Is there room for improvements? All such questions are suitable for simulation studies to evaluate and improve the protocol used by the EMD. Furthermore, how is the attitude towards T-CPR among EMDs? Do they sometimes hesitate to start CPR instructions? If so, why? Is EMDs education and retraining regarding delivering of CPR-instructions optimal today? How can improvements be made?

CONCLUSIONS

The findings in our studies demonstrate that dispatchers do offer telephone guided CPR to bystanders in cases of OHCA but not to all cases where it was probably indicated. The first study confirmed that the occurrence of agonal respiration in association with CA is a hindrance to offering T-CPR. Few witnesses which were offered telephone-guided CPR refused to participate, this demonstrates a high willingness to provide help in these situations. In the second study a significantly higher proportion of patients were offered T-CPR after a specific 1-day tutorial for EMDs concerning agonal respiration. We therefore conclude that a brief tutorial comprising the signs and implications of agonal respiration has great impact on the likelihood of EMDs to offer T-CPR.

In the third study there was no significant difference in 1-month survival in patients who received standard CPR as compared to those given compression-only CPR. The fourth study, with a prospective randomized design, showed no significant difference in survival regarding dispatcher-assisted CPR when using compression-only CPR compared to standard CPR in witnessed OHCA. These two studies provide further support to the hypothesis, raised from previous studies, that compression-only CPR should be considered the preferred method in bystander CPR.

SUMMARY IN SWEDISH

Hjärtstopp är en vanlig dödsorsak. I Sverige dör 6 000- 10 000 personer per år av hjärtstopp utanför sjukhus. Hjärt- och lungräddning (HLR) kan rädda liv vid hjärtstopp. Målet med denna avhandling är att beskriva olika aspekter av HLR och larmoperatörens roll med syfte att öka andelen HLR vid hjärtstopp utanför sjukhus.

Metod och resultat: I **studie I**, analyserades 76 ljudinspelningar av larmsamtal angående hjärtstopp, från 315 konsekutivt insamlade fall utanför sjukhus under januari till maj 2004 med syfte att beskriva likväl frekvensen av som hinder för larmoperatörassisterad telefon-HLR (T-HLR). T-HLR erbjöds av larmoperatörer i 47% av fallen (n=36). Endast två inringare ville inte göra HLR. Tecken till agonal andning, beskrevs i 64% av fallen. HLR erbjöds i 23% (n=10) av fallen med agonal andning i jämförelse med 92% (n=23) utan agonal andning.

För att utvärdera om en speciell utbildning för larmoperatörer avseende agonal andning som ett tecken på hjärtstopp, kunde öka andelen erbjuden T-HLR, analyserades i **studie II** ytterligare 76 ljudinspelningar. Här ingick 55 konsekutivt insamlade fall av hjärtstopp utanför sjukhus mellan juni och augusti 2006 ingick. Analysen från studie I utgjorde en historisk kontrollgrupp. Före utbildningen erbjöds T-HLR i 47% (36) av fallen jämfört med 68% (52) efter en-dagsutbildningen om agonal andning (p=0.01). En ökning av erbjuden T-HLR sågs också i relation till agonal andning, 23% erbjöds T-HLR 2004 jämfört med 56% 2006 (p=0.006).

För att utvärdera tidig standard-HLR (mun-till-mun andning *med* bröstkompressioner) utförd av lekman jämfört med enbart bröstkompressioner inkluderades i **studie III** patienter med hjärtstopp utanför sjukhus som hade fått någon form av tidig hjärt- och lungräddning i väntan på ambulans och som var rapporterade till Nationella hjärtstoppsregistret mellan 1990 till 2005. Fall bevittnade av ambulanspersonal exkluderades. Det saknades information avseende vilken typ av tidig hjärt- och lungräddning som hade utförts i 1 465 (11%) fall. Av de återstående 11 275 patienterna hade 8 209 (73%) fått standard-HLR och 1 145 (10%) hade fått enbart kompressioner. Ingen signifikant skillnad kunde ses mellan grupperna avseende överlevnad vid 30 dagar.

I **studie IV** inkluderades misstänkta bevittnade hjärtstopp av larmoperatörer vid Sveriges larmcentraler mellan februari 2005 och januari 2009 för att randomiseras och erbjudas T-HLR om antingen standard-HLR eller enbart kompressioner. Primär utfallsvariabel var överlevnad vid 30 dagar. Totalt inkluderades 3 809 patienter. Efter exklusion enligt protokoll återstod 1276 patienter. Av dessa randomiserades 620 patientfall till telefoninstruktioner om enbart kompressioner och 656 patientfall till telefoninstruktioner om standard-HLR. Vid 30 dagar var överlevnaden jämförbar mellan grupperna: 8,7% (54/620) hos dem som fick enbart kompressioner 7,0% (46/656) hos dem som fick standard HLR (1,7 procentenheters skillnad, 95% CI för skillnaden var -1,2% to 4,6%; $p < 0.30$).

Konklusion: Larmoperatörer erbjöd T-HLR till lekmän vid fall av hjärtstopp utanför sjukhus, dock inte i alla fall som var möjliga. Agonal andning vid hjärtstopp var ett hinder för erbjudande av T-HLR. Få inringare som erbjöds T-HLR ville inte delta. En kort utbildning av larmoperatörer avseende agonal andning ledde till att en signifikant högre andel patienter som erbjöds T-HLR. I en registerstudie gällande hjärtstopp utanför sjukhus visade ingen signifikant skillnad vid 30 dagarsöverlevnad bland patienter som fått standard-HLR jämfört med enbart kompressioner. En prospektiv, randomiserad, nationell studie visade ingen signifikant skillnad mellan T-HLR instruktioner om standard-HLR jämfört med enbart kompressioner vid bevittnade hjärtstopp utanför sjukhus. Mot bakgrund av tidigare studier ger dessa studier stöd till hypotesen att enbart kompressioner är att föredra vid tidig HLR av lekman.

Nyckelord: hjärtstopp, hjärt- och lungräddning, larmoperatörledd HLR, agonal andning

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