



Rediscovering the importance of chest compressions to improve the outcome from cardiac arrest

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1. Background

The first guidelines for the treatment of patients with cardiac arrest were published in the 1970s [1] and these guidelines were updated in 1980 [2] and 1986 [3] stressed the importance of chest compressions. This followed naturally from the landmark paper by Kouwenhoven et al. that had been published only a few years earlier [4]. At the time, defibrillators were not as easy to use as their modern counterparts and resuscitation procedures concentrated on providing chest compression and ventilation.

With the recognition of the important role that early defibrillation plays in the treatment of patients in ventricular fibrillation (VF) and the technological advances that have made defibrillation easier, the focus changed. By 1992, published guidelines placed the emphasis on early defibrillation and relegated chest compression to a secondary role [5]. The proportion of time spent in providing CPR (as opposed to undertaking defibrillation) recommended in recent guidelines is summarised in Fig. 1, with current guidelines recommending CPR for only 50% of the resuscitation attempt.

Compared with 30 years ago, defibrillators (AEDs) are increasingly being provided in the community, yet the survival rate for patients with cardiac arrest has remained essentially unchanged.

We were concerned that inadequate provision of chest compressions might be an important factor in poor outcome and decided to investigate this. Recent research to support such an idea comes from the following studies:

- 1) The demonstration of improved performance of chest compressions by using a mechanical device, with an indication that this may result in increased survival [6].
- 2) Negative effects on coronary perfusion pressure (CPP) from interrupting chest compression in rats,

which correlated with adverse effects on the return of spontaneous circulation (ROSC) [7].

- 3) A rapid decline in CPP in rats when chest compression ceased. With a 20-s delay before defibrillation, there was a 24-h survival and with a 30-s delay there was a reduced rate of ROSC [8].
- 4) Retrospective studies from Oslo showing a minimum hands-off time required for rhythm analysis of 20 s. This delay reduced the probability of ROSC dramatically [9,10].
- 5) Animal data indicating that CPR before defibrillation improves outcome when arrest–defibrillation intervals are longer than a few minutes [11].
- 6) Data from a non-randomized study with a historic control group, indicating that CPR before defibrillation might improve outcome when intervals between arrest and defibrillation are longer than a few minutes [12].
- 7) The demonstration that prolonged VF causes metabolic degradation in the myocardium and that a more favourable response to shocks occurs when the heart is better prepared metabolically [13].
- 8) Emphasis placed on increased use of CPR after the administration of shocks because of the 1.5–4 min required to transport drugs and O₂ to vital organs [14–16].

2. The study [17]

The reports of decreasing chances of restarting the heart following increasing periods without chest compression (and therefore blood flow), led us to perform a study in Oslo to investigate strategies to minimize hands-off time. Critical to the process of maximising the time during which cardiovascular flow was generated, was the performance of 3 min of CPR before attempting defibrillation. Our protocol and the rationale for it is summarised in Fig. 2.

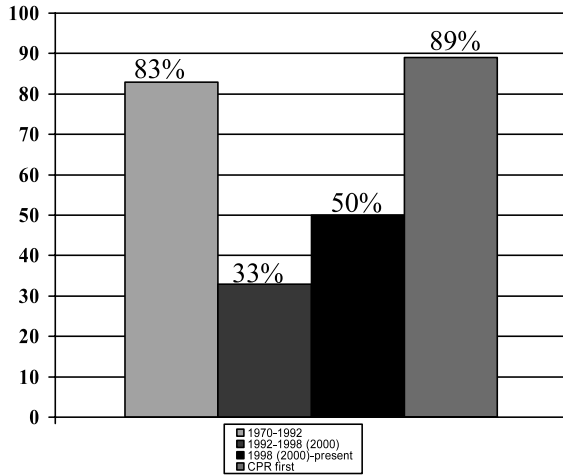


Fig. 1.

3. Methods

We conducted a randomised, controlled trial in patients over the age of 18 years with VF or pulseless VT, where the arrest had not been witnessed by ambulance personnel. The study was granted ethical approval, with a waiver of consent issued in accordance with paragraph 26 of the Declaration of Helsinki. Informed consent was obtained, however, for the collection and use of 1-year follow-up data.

Randomisation to standard treatment according to current ERC guidelines or ‘CPR-first’ was achieved at the scene by using sealed study envelopes after verification of VF/VT. The participating ambulance personnel could not be blinded thereafter. Hospital personnel, including the physicians responsible for assessing the

neurological outcome at hospital discharge, were blinded to the treatment strategy used. The study was monitored by a physician not involved in the care of patients or in data collection.

Data were recorded on an Utstein-style database from the digital ambulance dispatcher database, the ambulance records and the data collection sheets. Survival and neurological status (Glasgow-Pittsburgh outcome categories) at hospital discharge was obtained from the hospital records. One-year follow-up data were collected from a questionnaire sent to survivors or their relatives during May 2002. All data were stored in a common-relationship database, designed in FileMaker Pro 4.1 and analyzed using statistical package for social sciences SPSS.

The primary outcome was survival to hospital discharge. Secondary outcomes were survival to reach hospital with spontaneous circulation (ROSC), overall status (OPC), neurological status (CPC) at discharge, and survival and neurological status at 1 year. Before analyzing outcomes, we postulated that any survival benefit would be most evident in cases with longer response intervals, so it was decided before the analysis began to divide the subjects according to whether the response time was greater or less than 5 min.

Categorical data were analysed by the χ^2 (or Fisher Irwin) test and numerical data by the Mann–Whitney *U*-test. A logistic regression analysis was performed to determine whether membership of either group resulted in significantly different probabilities of survival. $P < 0.05$ was considered significant.

There were no differences in the baseline characteristics of the patients in the two groups. Overall, there were no differences in ROSC, survival, or survival for 1 year in the groups who received CPR initially compared

How much time is spent on flow generating activity during 7 min of CPR?

STANDARD METHOD

- ECG analyses and defib x 3 (45 sec)
- Chest compressions (60 sec)
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- Chest compressions (60 sec)
- ECG analyses and defib x 3 (45 sec)

57% on flow generating activity

CPR-FIRST METHOD

- Chest compressions (180 sec)
- ECG analyses and defib x 3 (45 sec)
- Chest compressions (180 sec)

89% on flow generating activity

Fig. 2.

with those who received standard treatment. Where the response time was >5 min, however, there was a significantly better outcome for all three variables in the ‘compression-first CPR’ group.

We calculated the estimated survival of patients who received CPR first compared with standard treatment as a function of response time interval.

When probability of survival is plotted as a function of the response time interval, a cross-over point is seen at 4 min, after which survival is better in those receiving CPR first instead of standard treatment. The calculated odds ratio for survival with CPR before defibrillation was 0.4 for a response interval of <1 min, but increased to 3 for a 7-min interval and further to 6.1 for a 9-min interval.

The conclusion from the study, therefore, is that performing CPR before defibrillation improves the outcome for patients in VF if the ambulance response time is >5 min, but makes no difference for shorter response time intervals [17].

Our conclusions concur well with the three-phase model of resuscitation proposed by Weisfeldt [18]. This proposes an initial electrical phase lasting 4 min during which defibrillation is the priority. This is followed by a circulatory phase lasting from 4 min up to ≈ 10 min, when the provision of circulation before attempted defibrillation becomes the priority. This in turn is followed by a metabolic phase where additional strategies, including the use of drugs and hypothermia, assume increasing importance.

In addition to performing 3 min of CPR before attempting defibrillation [17], we have reduced interruptions in CPR by the reintroduction of manual defibrillators that can be charged while CPR is in progress: manual ECG analysis can be achieved in approx. 3 s [10]. By adopting all these procedures, 90% of a resuscitation attempt can be spent performing CPR. It should be noted that this is exactly what was suggested in the very first guidelines [1].

Adherence to current resuscitation guidelines results in less time being spent on chest compression; increased hands-off intervals and suboptimal quality of CPR are additional factors that also reduce the provision of circulation. A new approach to resuscitation may well be justified in the light of recent scientific advances. Precisely what that approach should be is the subject of debate, but an increased focus on flow-generating activity, particularly by maximising the time spent performing chest compressions, is a crucial factor that will feature prominently in that debate.

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