Cardiopulmonary Resuscitation — Strengthening the Links in the Chain of Survival

Gordon A. Ewy, M.D. (N Engl J Med 2000; 342:1599-1601)

The major determinants of survival after witnessed out-of-hospital cardiac arrest due to ventricular fibrillation include whether a bystander initiates cardiopulmonary resuscitation (CPR) and how quickly defibrillation is accomplished.

Now-classic observations determined that among patients with out-of-hospital cardiac arrest due to ventricular fibrillation, 43 percent survived to leave the hospital if CPR was initiated by a bystander within four minutes and if definitive therapy was delivered within eight minutes. Survival decreased to less than 7 percent if basic CPR was not initiated until 8 minutes, and no patient survived after 16 minutes of untreated ventricular fibrillation.

Although bystander-initiated CPR is critical to survival after out-of-hospital cardiac arrest, the incidence of bystander-initiated CPR throughout the world is extremely low. In a survey of 975 laypersons instructed to assume that they knew how to do basic CPR, only 15 percent said they would definitely perform CPR that required mouth-to-mouth assisted ventilation on a stranger. In contrast, 68 percent said they would definitely perform CPR on a stranger if only chest compression were required. The vast majority had an aversion to mouth-to-mouth breathing, or a fear of infection.

An often espoused, but impractical, way to improve the frequency of bystander CPR would be for everyone to carry barrier masks. Another approach to the issue has been to investigate the actual need for assisted ventilation during the early phases of cardiac arrest due to ventricular fibrillation. Both experience and experimental studies have clearly shown that assisted ventilation is essential in respiratory arrest. In children and young adults, cardiac arrest is frequently secondary to respiratory arrest. However, at the time of sudden cardiac arrest due to ventricular fibrillation in adults, the pulmonary veins, left atrium, left ventricle, and entire arterial system are filled with oxygenated blood. To waste time by performing assisted ventilation before initiating chest compression does not make physiologic sense. The most reasonable response is prompt, rapid, forceful chest compression.

The primary determinant of the effectiveness of basic CPR in patients with ventricular fibrillation of recent onset is myocardial and cerebral perfusion, since the brain and the fibrillating heart continue to consume ATP and other energy sources. Without adequate perfusion, they become dysfunctional and eventually cease to function. For example, electric shocks in patients with prolonged ventricular fibrillation result in defibrillation not to a perfusing rhythm but to pulseless electrical activity or asystole.

Since the coronary and cerebral vessels are maximally dilated early in cardiac arrest, the chief factor in myocardial perfusion during basic CPR is the coronary perfusion pressure — that is, the aortic "diastolic" pressure (the pressure during the release phase of chest compression) minus the coronary-sinus or right atrial "diastolic" pressure. The cerebral perfusion pressure is related to the "systolic" pressure — or the pressure during the chest-compression phase of CPR.

Myocardial and cerebral perfusion pressure falls every time chest compressions are interrupted for assisted ventilation, and it takes time to build up the coronary perfusion pressure again once chest compressions are reinitiated. As a result, with a ratio of 15 compressions to 2 breaths, the highest perfusion pressures are present for less than half the time.

Several years ago, my colleagues and I became interested in CPR with chest compression only. One impetus for our interest was a recording that I heard from a research group in Seattle during its early experience with CPR performed by bystanders following telephone instructions from the emergency-medical-services dispatcher. After performing such telephone-instructed CPR for several minutes, a woman asked the dispatcher, "Why is it every time I press on his chest he opens his eyes, and every time I stop to breathe for him he goes back to sleep?" This simple observation was in accord with our experimental findings in animals. Over the past decade, our CPR research laboratory has studied cardiac arrest induced by ventricular fibrillation in swine; we have repeatedly shown that survival at 24 hours is similar when CPR includes only chest compression and when it involves the now-standard airway clearance, assisted breathing, and chest compression. More

important, survival with chest compression alone in our simulations is dramatically better than survival with no CPR performed by the bystander and chest compression delayed until the arrival of paramedics 8 to 12 minutes later.

The report by Hallstrom and associates from Seattle in this issue of the *Journal* is of immense importance and will have worldwide implications. It and the previous report from the same group are the most elegant studies to date that have confirmed in humans the laboratory finding in animals that in cases of witnessed sudden cardiac arrest with a nonrespiratory cause, CPR by chest compression alone is as good as, and possibly better than, the now standard CPR by compression plus ventilation. The setting of the trial reported by Hallstrom et al. was an urban, two-tiered emergency-medical-services system, based in a fire department with central dispatching and a receptive citizenry. In a randomized manner, telephone dispatchers gave bystanders at the scene of a cardiac arrest, instructions in either CPR by chest compression alone or CPR with both assisted breathing and chest compression.

The primary end point was survival to hospital discharge. A total of 241 patients were randomly assigned to receive chest compression alone and 279 to receive CPR with mouth-to-mouth ventilation. The rate of survival to hospital discharge was greater among patients assigned to chest compression alone than among those assigned to compression plus ventilation (14.6 percent vs. 10.4 percent), although this difference was not statistically significant (P=0.18). The investigators concluded that CPR by chest compression alone had an outcome similar to that with chest compression plus mouth-to-mouth ventilation and that chest compression alone may be the preferred approach for inexperienced bystanders.

The only other study that compared methods of CPR in a substantial number of cardiac arrests in humans was an observational study from Belgium. Paramedics observed the type and quality of CPR performed by a layperson when they arrived on the scene. They found that survival among patients who received well-performed chest-compression CPR was the same as survival among those receiving well-performed CPR consisting of compression plus mouth-to-mouth ventilation.

The landmark study by Hallstrom et al. has important implications for the future, since it will encourage efforts to reevaluate the way we teach and perform basic CPR. The investigators conclude, "We believe chest-compression CPR may be applicable to the more general setting of bystander-initiated CPR."

Authorities in CPR have come to realize that our standard method of performing basic CPR is difficult for the average layperson to learn, retain, and perform. It involves what is really a highly complicated set of psychomotor skills. Accordingly, Assar and associates studied the effect of teaching community CPR in three stages, which they called bronze, silver, and gold. At the first two-hour session, volunteers were taught chest compressions only; the instructors recommended 50 chest compressions followed by "brief pauses to recheck the airway and provide the rescuer a few moments of respite from relatively strenuous exertion." At the second session, they taught mouth-to-mouth assisted ventilation, and at the third session the now standard technique of airway clearance, assisted breathing, and chest compression. As part of a research project, selected students underwent an additional test after completion of instructions (exit testing, with video recording).

The performance of 269 subjects who were graduates of the chest-compression-only CPR group was compared with that of 236 subjects who had been taught standard basic CPR (the third step). The investigators found that the subjects who had been taught CPR with chest compression alone had better recall, experienced less confusion and hesitation in initiating chest compressions (starting within 34 seconds, as compared with 63 seconds), and were able to perform significantly more chest compressions per minute (84 vs. 39) than was the case in the group taught standard CPR with airway management, assisted breathing, and chest compression.

Our CPR research laboratory is currently comparing survival in groups of animals receiving compression and ventilation in ratios different from the standard 15-to-2 ratio. If newer methods involving more chest compressions and fewer breaths prove to be more effective in our animal

models, the study by Hallstrom and associates will help to encourage testing in humans with cardiac arrest.

Although slight improvements in basic CPR will save many lives, life cannot be sustained by CPR, whether it involves only chest compressions or assisted breathing and whatever the compression-to-ventilation ratio; these methods only slow the process of dying, buying precious minutes for definitive therapy, which consists of early defibrillation. An analysis of many studies has shown that the rate of survival after out-of-hospital cardiac arrest due to ventricular fibrillation decreases by 10 percent for each minute defibrillation is delayed. The results with the automatic external defibrillator parallel these findings. The use of automatic external defibrillators in locations where there are substantial numbers of people at risk and where paramedics' response times are inappropriately long will improve survival. Long response times are the rule when cardiac arrest occurs in airplanes, airports, ships, and some, if not most, large cities, high-rise office buildings or apartments, gated communities, golf courses, and gambling casinos.

It is clear that the weakest links in the chain of survival after out-of-hospital cardiac arrest due to ventricular fibrillation are the lack of bystander-initiated basic CPR and the delay in defibrillation. We can strengthen these two critical links by encouraging the prompt use of CPR with chest compression alone by bystanders and by encouraging the appropriate use of automatic external defibrillators.

Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation Hallstrom A, Cobb L, Johnson E, Copass M. (N Engl J Med 2000; 342:1546-1553)

ABSTRACT

Background Despite extensive training of citizens of Seattle in cardiopulmonary resuscitation (CPR), bystanders do not perform CPR in almost half of witnessed cardiac arrests. Instructions in chest compression plus mouth-to-mouth ventilation given by dispatchers over the telephone can require 2.4 minutes. In experimental studies, chest compression alone is associated with survival rates similar to those with chest compression plus mouth-to-mouth ventilation. We conducted a randomized study to compare CPR by chest compression alone with CPR by chest compression plus mouth-to-mouth ventilation.

Methods The setting of the trial was an urban, fire-department–based, emergency-medical-care system with central dispatching. In a randomized manner, telephone dispatchers gave bystanders at the scene of apparent cardiac arrest instructions in either chest compression alone or chest compression plus mouth-to-mouth ventilation. The primary end point was survival to hospital discharge.

Results Data were analyzed for 241 patients randomly assigned to receive chest compression alone and 279 assigned to chest compression plus mouth-to-mouth ventilation. Complete instructions were delivered in 62 percent of episodes for the group receiving chest compression plus mouth-to-mouth ventilation and 81 percent of episodes for the group receiving chest compression alone (P=0.005). Instructions for compression required 1.4 minutes less to complete than instructions for compression plus mouth-to-mouth ventilation. Survival to hospital discharge was better among patients assigned to chest compression alone than among those assigned to chest compression plus mouth-to-mouth ventilation (14.6 percent vs. 10.4 percent), but the difference was not statistically significant (P=0.18).

Conclusions The outcome after CPR with chest compression alone is similar to that after chest compression with mouth-to-mouth ventilation, and chest compression alone may be the preferred approach for bystanders inexperienced in CPR.

Methods Fire-department dispatchers followed a structured interrogation protocol with two basic questions: "Is the patient conscious or awake?" and "Is the patient breathing normally?" If the answers to both of these questions were "no" or equivocal, an emergency-medical-services team was immediately dispatched and the caller was assured that help was on the way; in addition, if there was no one on the scene who was already performing (or intending to perform) CPR, and if the caller was willing to be instructed, the caller was given instructions for performing either chest

compression alone or chest compression plus mouth-to-mouth ventilation (see figure below), as randomly assigned by a microcomputer located at the dispatcher's console.