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CARDIOPULMONARY RESUSCITATION BY CHEST COMPRESSION ALONE OR WITH MOUTH-TO-MOUTH VENTILATION

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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. (N Engl J Med 2000;342:1546-53.)

ALTHOUGH bystander-initiated cardiopulmonary resuscitation (CPR) has been associated with an increase of 50 percent or more in survival after out-of-hospital cardiac arrest, and despite extensive training of citizens in CPR techniques,[1,2] approximately half of the victims of witnessed out-of-hospital cardiac arrests in the Seattle–King County, Washington, area during the past few decades did not receive bystander-initiated CPR. To address this problem, investigators in King County initiated a program in which dispatchers were taught to instruct callers in how to initiate CPR.[3,4] The instructions included airway management, mouth-to-mouth ventilation, and chest compression. The investigators reported that dispatcher-instructed CPR by bystanders was associated with a rate of survival to hospital discharge that was similar to the historical experience with bystander-initiated CPR, that the time required to provide the instructions averaged 2.4 minutes, and that the most common reason for not completing the instructions was the arrival of emergency-medical-services personnel.

Since the average interval to a response in Seattle was 3.1 minutes, as compared with 4.5 minutes in the suburban communities where the King County study was conducted, it was unclear whether implementing such a program in Seattle might simply be a drain on dispatch-center resources. In addition, studies in animals, particularly those by Meursing et al.,[5] demonstrated that central arterial oxygenation remains relatively high for a substantial time after the onset of ventricular fibrillation.

In 1989 we therefore began a preliminary trial of dispatcher-instructed bystander CPR that compared the value of instructions for chest compression only with that of standard instructions for chest compression plus mouth-to-mouth ventilation. After approx-

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imately 200 victims had been enrolled, the study was terminated because the conditional power of rejecting the null hypothesis (i.e., that chest compression and chest compression plus mouth-to-mouth ventilation result in similar rates of survival to hospital discharge) in favor of superiority of chest compression plus mouth-to-mouth ventilation was low. Moreover, since the trial began, a preliminary study using a swine model of ventricular fibrillation was published and suggested that chest compression alone might be as effective as chest compression plus ventilation, even after 10 minutes of ventricular fibrillation.[6] In addition, questions were being raised about the safety of mouth-to-mouth ventilation, because of the epidemics of the acquired immunodeficiency syndrome and hepatitis C.[7]

Accordingly, we initiated a new trial to test the one-sided alternative hypothesis that dispatcher-instructed bystander CPR by chest compression alone would yield an absolute increase of at least 3.5 percent (the observed difference when the first trial was stopped) in survival to hospital discharge over dispatcher-instructed chest compression plus mouth-to-mouth ventilation by bystanders.

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 (Fig. 1), as randomly assigned by a microcomputer located at the dispatcher's console.

Data from 776 cases randomly assigned to treatment were excluded from the analysis for the a priori reasons shown in Table 1. For all episodes, including those which met the a priori exclusion criteria, data were collected from the microcomputers (responses to the interrogation and randomization assignments), the paramedics' field report, the recorded dispatch call, and the hospital record (for patients who were admitted). At hospital discharge, a simple assessment of neurologic morbidity was obtained (with the patient assigned to one of the following categories: no apparent morbidity; some impairment, but able to carry out activities of daily living; morbidity sufficient to require some, but not complete, assistance; or morbidity requiring complete care). Information on survival status was obtained yearly.

At the end of the study (in August 1998), all patients who had survived to discharge from the hospital or their families were contacted, and their vital status and degree of residual morbidity were assessed. All callers who were given instructions were telephoned approximately one to two months after the episode and, if they consented, underwent a structured interview, including questions about the episode, the victim, the caller, the dispatcher's instructions, and the implementation of those instructions. In addition, the callers were asked whether they had any physical or emotional problems related to their participation.

As far as possible, the study was blinded. Emergency-medical-services personnel other than those in the dispatch office were generally unaware that an episode might be part of a trial. Moreover, the paramedics who completed the field reports typically arrived after the first responding personnel and thus had limited knowledge of the type or quality of bystander CPR that may have been performed. Exclusions were based on information taken directly from the paramedics' field reports (including cases in which there was no cardiac arrest; cases of drug overdose, alcohol intoxication, or carbon monoxide poisoning; cases in which advanced cardiac life support was not carried out; and cases due to trauma) and on information from the dispatch recording (the caller was not at the scene, or cardiac arrest occurred after the call). Hospitalization data and functional status after discharge from the hospital were obtained through an existing follow-up program whose personnel were unaware of the treatment assignments.

The primary end point was survival to hospital discharge. Secondary end points included admission to the hospital and estimated neurologic status in the survivors.

The trial was designed to test the alternative one-sided hypothesis that dispatcher-instructed chest-compression CPR was associated with at least a 3.5 percent improvement in the absolute rate of survival to hospital discharge over the rate with chest compression plus mouth-to-mouth ventilation. However, only two-sided P values are reported. Enrollment in the trial began on January 15, 1992, and continued through August 30, 1998. The projected number of episodes of out-of-hospital cardiac arrest during this period was 700. However, because of limited funding, the study was planned for a fixed period. Monitoring of results (following Fleming et al.[8]) was conducted three times, after approximately 150, 300, and 450 episodes had occurred. The emphasis was on compliance and safety, and the reviewers were blinded only to the primary outcome. The protocol was approved by the investigational review board of the University of Washington, the Seattle Fire Department, and the legal authorities of the city of Seattle.

The primary analysis consisted of a simple comparison of proportions by Fisher's exact test. We conducted secondary analyses using logistic-regression analysis to adjust for characteristics of the patients and the episodes.

RESULTS

Enrollment in the trial was terminated according to the schedule on August 30, 1998, at which time there had been 1296 randomized episodes of cardiac arrest. Of these, 776 were excluded from the analysis on the basis of a priori criteria, which fell mainly into three categories: absence of cardiac arrest; cardiac arrest due to drug overdose, alcohol intoxication, or carbon monoxide poisoning; or no provision of advanced cardiac life support (Table 1). The true cause was determined for 249 of the 260 episodes initially misdiagnosed as cardiac arrests; most of these were attributed to stroke or transient ischemic attack (24.1 percent), seizure (20.9 percent), or syncope (20.5 percent) (Table 2). Of the 520 cases randomly assigned to treatment and included in the analysis, 279 were assigned to chest compression plus mouth-to-mouth ventilation and 241 to chest compression alone ($P=0.10$). The characteristics of the episodes and the patients were similar in the two treatment groups (Table 3), with the exception of race or ethnic group. The victims averaged 68 years of age, 64 percent were male, 58 percent of the episodes were witnessed (i.e., the collapse was seen or heard) and 88 percent occurred in a home. The time to response by the first emergency vehicle averaged 4.0 minutes; all of these units were equipped with automated defibrillators.

Data on discharge were not available for two patients who were admitted to the hospital, one in each

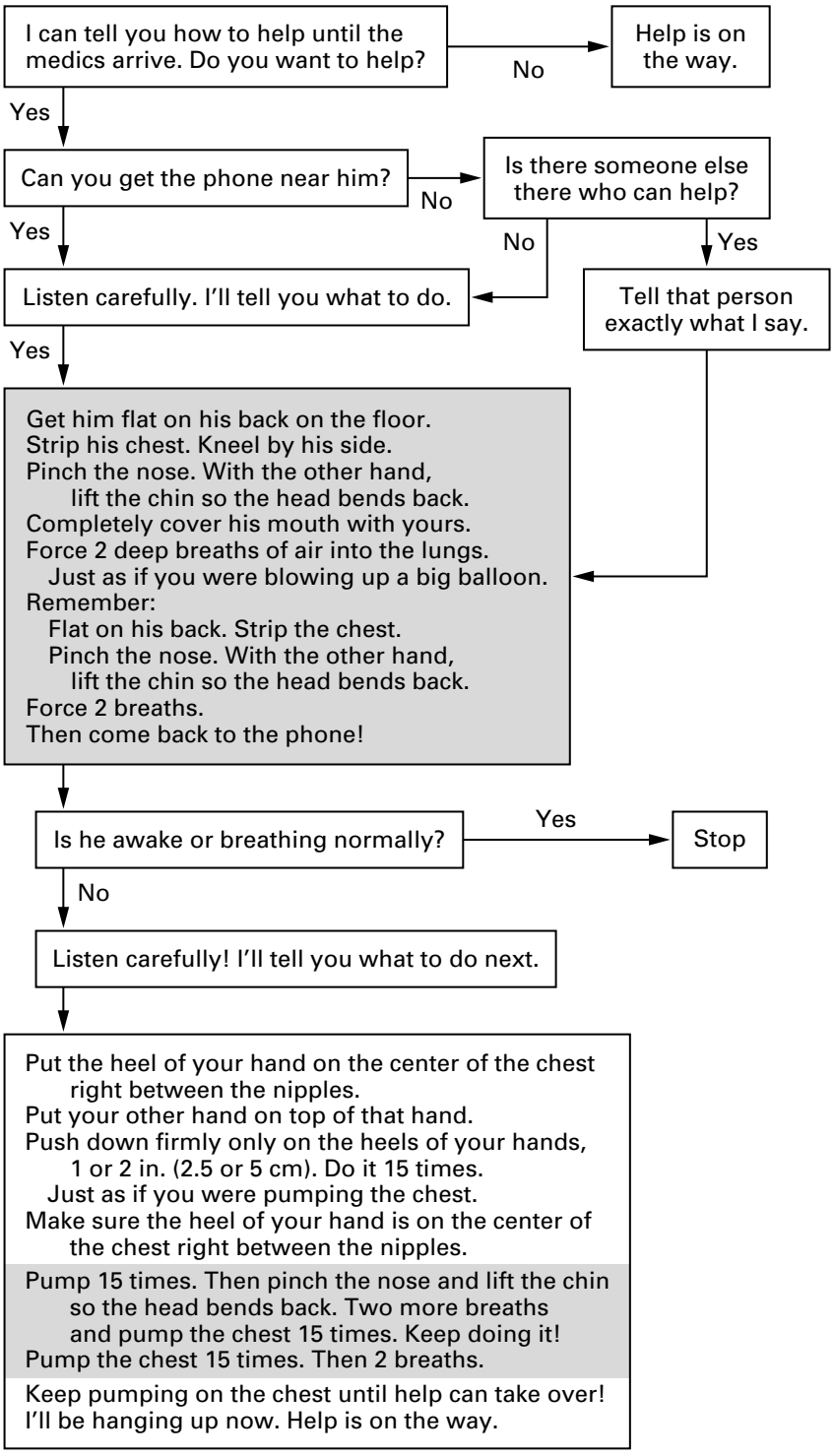

Figure 1. Protocol for Standard Instructions for CPR by Chest Compression Combined with Mouth-to-Mouth Ventilation.

The instructions for CPR by chest compression alone do not include the shaded sections. In this example it is assumed that the victim is male.

TABLE 1. REASONS FOR THE EXCLUSION OF 776 RANDOMIZED EPISODES.

REASON FOR EXCLUSION	CHEST COMPRESSION PLUS MOUTH-TO-MOUTH VENTILATION (N=403)	CHEST COMPRESSION ALONE (N=373)	P VALUE	TOTAL
	number (percent)			%
No cardiac arrest*	151 (37.5)	119 (31.9)	0.12	34.8
Apparent drug overdose, alcohol intoxication, or carbon monoxide poisoning	117 (29.0)	110 (29.5)	0.94	29.3
Caller not at the scene†	1 (0.2)	0	1.00	0.1
Advanced cardiac life support not performed	128 (31.8)	138 (37.0)	0.13	34.3
Trauma	5 (1.2)	2 (0.5)	0.45	0.9
Cardiac arrest occurred after request for assistance	1 (0.2)	4 (1.1)	0.21	0.6

*Of the 270 cases not due to cardiac arrest, 260 were assigned to treatment because the dispatcher mistakenly diagnosed them as due to cardiac arrest; the other 10 cases were not diagnosed as due to cardiac arrest, but were still assigned to treatment for unknown reasons.

†This category consists of relayed calls, radio contact, and commercial ambulance calls.

TABLE 2. CAUSES OF 260 RANDOMIZED EPISODES INCORRECTLY IDENTIFIED BY THE DISPATCHER AS CARDIAC ARRESTS.*

CAUSE	CHEST COMPRESSION PLUS MOUTH-TO-MOUTH VENTILATION (N=145)	CHEST COMPRESSION ALONE (N=115)	TOTAL
	number (percent)†		%
Stroke or transient ischemic attack	33 (24.1)	27 (24.1)	24.1
Seizure	28 (20.4)	24 (21.4)	20.9
Syncope	26 (19.0)	25 (22.3)	20.5
Other	27 (19.7)	18 (16.1)	18.1
Drug overdose	14 (10.2)	9 (8.0)	9.2
Alcohol intoxication	4 (2.9)	5 (4.5)	3.6
Trauma	2 (1.5)	1 (0.9)	1.2
Possible respiratory arrest	2 (1.5)	1 (0.9)	1.2
Congestive heart failure or pulmonary edema	1 (0.7)	2 (1.8)	1.2

*Ten of the 270 cases not due to cardiac arrest were not diagnosed as due to cardiac arrest, but were still assigned to treatment for unknown reasons; these 10 cases are not included here.

†The percentages are based on the 249 cases with known causes, 137 in the group assigned to chest compression plus mouth-to-mouth ventilation and 112 in the group assigned to chest compression alone.

treatment group. A total of 64 patients survived to discharge from the hospital: 29 (10.4 percent) in the group receiving chest compression plus mouth-to-mouth ventilation, and 35 (14.6 percent) in the group receiving chest compression only (Table 4) (P=0.18). The secondary end point of admission to the hospital showed a similar pattern favoring chest compression alone (P=0.15).

Adjustment for characteristics of the episode (age, sex, and race or ethnic group of the victim[9]; location of the episode[10]; whether the episode was witnessed; response time; coexisting conditions[11]; and the presence or absence of symptoms before the episode) by logistic regression did not substantially change either the estimates of effect or the significance levels for the end points of survival to hospital discharge and admission to the hospital. For survival to hospital discharge, the unadjusted odds ratio for the compression-plus-ventilation group as compared with the compression-only group was 0.68 (P=0.15), and the adjusted odds ratio was 0.75 (P=0.31), with location (odds ratio, 0.59; P<0.001), whether the arrest was witnessed (odds ratio, 2.32; P=0.0025), and age (odds ratio, 1.0213; P=0.02) as significant predictors. For admission to the hospital, the unadjusted odds ratio was 0.77 (P=0.14), and the adjusted odds ratio was 0.80 (P=0.26), with location (odds ratio, 0.69; P=0.01) and whether witnessed (odds ratio, 3.34; P<0.001) significant predictors.

During the trial, the paramedics responded to 4189 cardiac arrests, 253 respiratory arrests, and 38 possible respiratory arrests. Of these, 520 occurred after the call for help. In 630 cases, the dispatchers did not attempt a diagnosis, usually because it was a relayed call or the patient was in an inaccessible location; in another 155, it was not possible to determine the dispatcher's diagnosis. Of the remaining 3175 cardiac arrests, the dispatchers correctly identified 2749 and failed to recognize 426 (13.4 percent), typically because of insufficient information.

Data from 227 patients who were randomly assigned to treatment for possible cardiac arrest were

TABLE 3. CHARACTERISTICS OF PATIENTS AND EPISODES.*

CHARACTERISTIC	CHEST COMPRESSION PLUS MOUTH-TO-MOUTH VENTILATION (N=279)	CHEST COMPRESSION ALONE (N=241)
Mean age (yr)	68.5	67.9
Male sex (%)	64.9	62.2
Race or ethnic group (%)		
White	81.0	72.2
Black	8.1	16.1
Native American	0.0	0.9
Asian	8.9	9.1
Hispanic	1.6	0.9
Other	0.4	0.9
Season (%)		
Winter (Nov.–Feb.)	33.7	32.8
Spring (March–June)	35.5	39.0
Summer or fall (July–Oct.)	30.8	28.2
Location (%)		
Home	89.2	87.1
Other residence	4.3	5.4
Public, indoors	2.5	5.0
Public, outdoors	3.9	2.5
Episode unwitnessed (%)	43.2	41.4
Mean first-unit response interval (min)	4.0	4.1
First cardiac rhythm or state (%)		
Ventricular fibrillation	41.6	44.4
Asystole	40.9	37.8
Pulseless electrical activity	16.1	17.0
Ventricular tachycardia	0.4	0.8
Unknown	1.1	0.0
No. of coexisting conditions (%)†		
0	25.8	27.0
1	49.1	49.0
2	21.1	20.7
3	3.9	3.3
Acute symptoms before episode (%)		
None	76.3	78.4
≤1 hr before episode	3.9	6.6
>1 hr before episode	19.7	14.9
CPR instructions completed (%)	61.6	80.5
Possible adverse effects on patient (%)	1.8	3.7

*Because of rounding, not all percentages total 100.

†The coexisting conditions were cancer, cardiac disease, and diabetes.

excluded from the primary analysis because the patients apparently had drug overdoses, alcohol intoxication, or carbon monoxide poisoning. Among these patients, 80.7 percent (88 of 109) of those receiving chest compression plus mouth-to-mouth ventilation and 75.7 percent (78 of 103) of those receiving chest compression alone survived to hospital discharge (P= 0.39). The survival status of 15 patients was unknown. When included episodes and episodes that were excluded because of apparent drug overdose, alcohol intoxication, or carbon monoxide poisoning are combined, survival to hospital discharge was 30.2 percent (117 of 387) in the group receiving chest compression plus mouth-to-mouth ventilation and 32.9 percent (113 of 343) in the group receiving chest compression alone, a nonsignificant difference of 2.7 percentage points (95 percent confidence interval, −4.1 to 9.5 percentage points).

The dispatchers mistakenly diagnosed a total of 260 cases not due to cardiac arrest as being due to cardiac arrest and randomly assigned them to treatment groups. Another 10 cases that were not due to cardiac arrest were not diagnosed as due to cardiac arrest, but were still assigned to treatment for unknown reasons. Among these 270 episodes, instructions were started in only 14 and completed in 7, primarily because the process of getting the patient to the floor resulted in additional information that allowed the dispatcher to realize the mistake. Data from the dispatch tapes, paramedics' reports, and telephone interviews showed no serious adverse effects on either the patient or the caller in any of these 270 episodes, and in particular in any of the 14 episodes in which CPR was started after instruction from the dispatcher.

Only 20 dispatcher-instructed bystanders (14 given instructions for chest compression plus mouth-to-mouth ventilation, 4 given instructions for chest com-

TABLE 4. PRIMARY AND SECONDARY OUTCOMES ACCORDING TO TREATMENT GROUP.

OUTCOME	CHEST COMPRESSION PLUS MOUTH-TO-MOUTH VENTILATION	CHEST COMPRESSION ALONE	TWO-SIDED P VALUE	DIFFERENCE (95% CI)*
	no./total no. (%)			%
Discharged alive (primary outcome)	29/278 (10.4)	35/240 (14.6)	0.18	4.2 (−1.5 to 9.8)
Admitted to the hospital	95/279 (34.1)	97/241 (40.2)	0.15	6.1 (−2.1 to 15.0)

*CI denotes confidence interval.

pression only, and 2 given instructions only to move the patient to the floor) reported adverse effects on themselves. These were not serious, ranging from "out of breath" to "vomit from patient." Similarly, few of the bystanders reported adverse effects of dispatcher-instructed CPR on the patients (7 of those given chest compression plus mouth-to-mouth ventilation and 10 of those given chest compression only). These included "patient vomited after breaths" to "sound of rib crack as chest compressions done."

The compliance of the dispatchers — that is, strict adherence to the written dispatch protocol — was generally above 90 percent for each step of the protocol, except for stating that help was on the way before pursuing the question of CPR, which had a compliance rate of only 75 percent. Ninety percent of callers, when asked, accepted the offer of CPR instruction. In 1 percent of the cases assigned to chest compression plus mouth-to-mouth ventilation, the dispatcher mistakenly gave instructions for chest compression alone; in 2 percent of the cases assigned to chest compression alone, the dispatcher mistakenly gave instructions for chest compression plus mouth-to-mouth ventilation.

The instructions were completely delivered in only 62 percent of the episodes assigned to chest compression plus mouth-to-mouth ventilation, as compared with 81 percent of the episodes assigned to chest compression alone ($P=0.005$). The arrival of emergency-medical-services personnel was the primary reason instruction was not completed, accounting for 58 instances of incomplete instructions among the 279 cases (20.8 percent) in the group assigned to chest compression plus mouth-to-mouth ventilation and 19 among the 241 cases (7.9 percent) in the group assigned to chest compression. In 5 percent of the episodes in both groups, the arrival of a bystander trained in CPR terminated the instructions.

Callers receiving instructions in chest compression plus mouth-to-mouth ventilation were more likely to terminate them by hanging up or declaring them too difficult than were callers receiving instructions in chest compression alone (7.2 percent vs. 2.9 percent). The inadequacy of the protocol was responsible for 91 percent of the nonarrests diagnosed as arrests, and dispatcher error for only 9 percent; however, dispatcher error was responsible for 70 percent of the cardiac arrests that were diagnosed as nonarrests, and protocol inadequacy for only 4 percent.

DISCUSSION

These data demonstrate that a strategy of dispatcher-instructed chest compression plus mouth-to-mouth ventilation was no better than a strategy of dispatcher-instructed chest compression alone in Seattle, where there is a two-tier system with relatively short response times and a tightly structured dispatch protocol. Although the differences were not statistically significant, the rates of survival to hospital discharge were higher with chest compression alone than with chest compression plus mouth-to-mouth ventilation (29 percent higher) as was the rate of admission to the hospital (15 percent higher). The estimated effect of the type of instruction was not changed by adjustment for base-line characteristics of patients and emergency medical services.

Since this trial was operationally identical to the preliminary trial described in the Introduction, it is appropriate to examine the combined data from the two studies. Of 400 patients randomly assigned to chest compression plus mouth-to-mouth ventilation, 134 (33.5 percent) were admitted to the hospital, as compared with 141 of 352 (40.1 percent) randomly assigned to chest compression alone ($P=0.07$). Over the course of both trials, 91 patients are known to have survived to discharge from the hospital — 44 of 399 (11.0 percent) assigned to chest compression plus mouth-to-mouth ventilation and 47 of 351 (13.4 percent) assigned to chest compression alone ($P=0.37$). Their vital status and degree of residual morbidity at the end of the study (after an average of 2.4 years of follow-up) are summarized in Table 5.

A limitation of this study is that we did not follow a strict intention-to-treat analysis. This was the case because data from many patients who were randomly assigned to treatment were excluded from the analysis for a priori reasons. With out-of-hospital cardiac arrest, it would not be appropriate to have dispatchers take the time to ask for information about all exclusion criteria before implementing the protocol. The exclusions are critical for two reasons. First, including data in the analysis on patients who did not have cardiac arrest would artifactually increase the survival rate, since most of these patients survived. Similarly, most patients with drug overdoses, alcohol intoxication, or carbon monoxide poisoning were resuscitated after respiratory arrest and hence were also survivors. Second, if patients who received no advanced cardiac life support (from whom CPR was withheld because it was considered futile or for some other reason) were included, the effect would be to reduce the survival rate, since all such patients died. The reasons for exclusion did not differ significantly between the treatment groups (Table 1).

An additional limitation of this study is that the true worth of providing CPR instructions before the arrival of emergency medical services has not been established. However, the prevailing opinion at this time is that bystander-initiated CPR is a highly effective aid to resuscitation from cardiac arrest.[2] Moreover, a difference in survival rates for episodes of ventricular fibrillation that were entered in the study as compared with those not entered (24 percent vs. 29 percent) was explained by differences in the characteristics of the episodes (84 percent vs. 47 percent occurred at home, and the victims averaged 69 vs. 66 years of age). The

TABLE 5. NEUROLOGIC MORBIDITY AMONG SURVIVORS TO HOSPITAL DISCHARGE, BASED ON COMBINED TRIAL DATA.

AT DISCHARGE	AT END OF STUDY*	CHEST COMPRESSION PLUS MOUTH-TO-MOUTH VENTILATION	CHEST COMPRESSION ALONE
		number	
No morbidity	Alive	22	21
Some morbidity	Alive, morbidity resolved	2	5
	Alive, morbidity unresolved	0	3
No morbidity	Dead	9	9
Some morbidity	Dead, morbidity had resolved	3	1
	Dead, morbidity was unresolved	8	8
Total		44	47

*The study ended in August 1998. The mean follow-up was 2.4 years (range, 0.03 to 8.8).

risks and costs of providing CPR instructions before the arrival of emergency medical services are minimal, and the benefits are at least probable.

In considering the relative advantages of providing instructions for chest compression plus mouth-to-mouth ventilation or for chest compression alone before the arrival of emergency medical services, several features of out-of-hospital cardiac arrest warrant consideration. First, the instructions are provided primarily to bystanders who have had little or no CPR training. Instructions for performing ventilation are time-consuming and difficult to carry out, whereas instructions for performing chest compression are relatively simple. Second, it is assumed that experienced personnel will soon be on the scene. In addition, cardiac arrest due to primary ventilatory failure is much less common than arrest due to cardiac causes, except in children and in cases of drug overdose, alcohol intoxication, or carbon monoxide poisoning. Thus, if the latter conditions are excluded, giving instructions for chest compression would appear to be more useful than attempting to deliver the more complex and perhaps unnecessary additional instructions for ventilation. It is possible, however, that simple instructions for opening the upper airway could be added to the chest-compression message. It is relevant to note that in this study, the survival of patients with apparent drug overdoses, alcohol intoxication, or carbon monoxide poisoning was similar in the two treatment groups (80.7 percent of those receiving chest compression plus mouth-to-mouth ventilation and 75.7 percent of those receiving chest compression alone).

The question of whether dispatchers might be able to distinguish which cases should receive instructions for chest compression plus mouth-to-mouth ventilation rather than chest compression alone is interesting. In our study, patients with drug overdoses, alcohol intoxication, or carbon monoxide poisoning were much younger than other patients (37±10 vs. 68±15 years), were less likely to have collapsed at home (58 percent vs. 88 percent), and were much more likely to have collapsed at another residence (38 percent vs. 5 percent).

CPR instruction of some type was given in 550 episodes of cardiac arrest, thus providing an additional 12.3 percent of all 4480 victims of cardiac arrest with some treatment before the arrival of emergency medical services. A somewhat unexpected benefit was that, in an additional 207 episodes, bystanders who had previously been trained in CPR indicated they had performed CPR because the dispatcher had prompted them and given them a quick review.

Are the results of this study applicable to other settings? During the almost seven years of the trial, substantial laboratory work has been done on the issue of ventilation during CPR. This is well summarized in a special report from the Ventilation Working Group of the Basic Life Support and Pediatric Life Support subcommittees of the American Heart Association.[12] The committee concluded that "it seems possible that mouth-to-mouth ventilation is not needed during the first few minutes of sudden witnessed circulatory arrest . . . and may, in fact, have . . . potential disadvantages, including gastric insufflation and less cycle time spent on effective chest compressions." The committee did not recommend that the guidelines be changed, largely out of concern for the usefulness of ventilation for arrests due to primary respiratory causes. Given the committee's appraisal and the results of this trial, we believe chest-compression CPR may be applicable to the more general setting of bystander-initiated CPR.

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