In-Hospital Cardiopulmonary Resuscitation: A 30-Year Review

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Abstract: ***Background:*** **We performed a meta-analysis to (1) assess the disputed issue of in-hospital cardiopulmonary resuscitation (CPR) success rates among elderly patients, (2) investigate the possibility of a declining CPR success rate between 1960 and 1990, (3) provide an overview estimate of CPR effectiveness in specific patient groups, and (4) assess CPR risks.**

Methods: **Ninety-eight reports providing in-hospital CPR survival-to-discharge rates were included in this overview. These reports were identified from MEDLINE searches, previous reviews, and reference citations.**

Results: **A pooled analysis revealed that 2994 (15 percent) of 19,955 patients were successfully resuscitated (survival to discharge). The rate of successful CPR has not changed in 30 years ($r = -0.14$, $P > 0.05$), but there has been a steady decline in the optimism regarding its value ($r = -0.29$, $P < 0.01$). Patients younger than 70 years of age had a success rate of 16.2 percent (odds ratio = 1.36; 95 percent confidence interval, 1.20 to 1.53) versus 12.4 percent for patients older than 70 years ($P < 0.001$). Community hospitals had a higher CPR success rate than teaching hospitals (18.5 percent versus 13.6 percent, $P < 0.001$). Although 72.9 percent of the post-CPR deaths were within 72 hours, prolonged in-hospital survival in a vegetative state did occur; 1.6 percent of successfully resuscitated patients had a permanent neurological impairment.**

Conclusion: **The increasing pessimism about the value of CPR, specifically, its futility in the elderly patient, is not supported by this review. The results of this meta-analysis should assist both the physician and the patient in determining the probable outcome of CPR. (J Am Board Fam Pract 1993; 6:91-101.)**

In 1990, the 30th anniversary of modern cardiopulmonary resuscitation (CPR), Youngner[1] noted that "Although CPR was initially seen as a dramatic and lifesaving intervention, its promise has faded with experience." Current debates[1-3] now include the appropriateness and even futility of CPR, especially in the elderly.

In an authoritative and highly recommended review, Safar[4] traced the roots of resuscitation medicine to antiquity and found them inseparable from the history of medicine in general. The modern era of CPR, however, began in 1960 with the report by Kouwenhoven and colleagues,[5] researchers from Johns Hopkins, of a 70 percent survival-to-discharge rate in patients undergoing closed-chest CPR. This astonishing result has never been duplicated. Other reports of in-hospital CPR success rates have varied from 3 percent to 56.2 percent.[6-103] Murphy, et al.[10] claimed that CPR success rates were "decreasing steadily" but provided no citations. Two recent reports[9,10] noted low CPR success rates among elderly patients and suggested that age was a negative predictor of CPR outcome. An editorial[104] labeled CPR a "curse" for most elderly patients and the health care system. A review by the Office of Technology Assessment concluded, however, that age was not a good predictor of CPR outcome.[3]

This comprehensive review and meta-analysis was undertaken to (1) assess the disputed issue of in-hospital CPR success rates among elderly patients, (2) investigate the possibility of a declining CPR success rate between 1960 and 1990, (3) provide an overview estimate of CPR effectiveness in specific patient groups, and (4) assess CPR risks.

Methods

Data were obtained from published reports of CPR outcomes. The reports in this review were obtained by (1) MEDLINE computer searches of the literature from 1966 through July 1990 using

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the indexing terms "cardiopulmonary resuscitation," "resuscitation," and "heart arrest"; (2) manual searches of references cited in published reports; and (3) previous reviews.[6-8]

Ninety-eight reports[5-7,9-103] were included in this review and meta-analysis by meeting the following criteria: (1) CPR was performed in-hospital, (2) the study included 5 or more patients, (3) the patients were exclusively or predominantly adult, (4) data for patient survival-to-discharge were available, (5) the report was published between July 1960 and July 1990, and (6) the report was written in English. Sixty-seven (68.4 percent) reports* were from the United States, including 25 states and the District of Columbia. Six of the reports[5,12,34,44,72,95] were from Baltimore; of these, four were from the Johns Hopkins Hospital[5,12,34,95] — the most reports from a single institution. The data from Johns Hopkins, however, accounted for only 1.4 percent (286/19,955) of the total patients in this review. No institution or city predominated. The 31 foreign reports† were from eight different countries, including 12 from England‡ and eight from Canada.[17,29,45,54,57,63,68,86] Only those reports that allowed pooling of the data were included in the group and subgroup comparisons.

Various statistical tests were employed in this review and meta-analysis. χ^2_c refers to the standard chi-square test with Yates' continuity correction[105]; z represents the Yusuf, et al.[106] adaptation of the Mantel and Haenszel method[107,108]; χ^2_h refers to a test for heterogeneity; and r refers to the coefficient of correlation.[105] The customary value of a two-sided $P \leq 0.05$ was used. Data were analyzed with Appleworks (version 3.0)[109] spreadsheets on Apple IIe computers.

Results

Overview

A successful resuscitation was defined, for the purpose of this report, as survival-to-discharge from the hospital. In this 30-year review of the literature, 19,955 patients from 98 studies[5-7,9-103] underwent in-hospital CPR for cardiac arrest, and 2994 (15 percent) of these patients were successfully resuscitated.

Sustained Survival

Unfortunately, short-term survival following CPR was variously defined.[6] One review[6] found short-term survival present in 38.5 percent (3865/10,042) of patients when it was defined as post-CPR survival for at least 24 hours.

Pooled estimates from 20 reports§ of CPR survival following discharge from the hospital (long-term survival) revealed a 90.2 percent rate of survival at 3 months, 82.6 percent at 6 months, 72.7 percent at 12 months, 54.6 percent at 24 months, and 44 percent at 36 months. Unfortunately, only two reports[7,79] provided rates for 5-year survivorship, and their results differed markedly: Peatfield, et al.[79] reported that 56 (60.2 percent) of 93 patients survived at least 5 years after discharge from the hospital, but DeBard[7] noted only 14 (20.3 percent) of 69 patients were alive after 5 years.

Group Comparisons

Age

Using 33 reports that allowed pooling of data by age, we found a 16.2 percent (597/3692) CPR success rate for patients younger than 70 years versus 12.4 percent (259/2093) for those older than 70 years ($z = 5.01$, $P < 0.001$; $\chi^2_h = 26.08$, $df = 32$, $P > 0.05$) (Table 1). Four of these reports[30,47,62,83] used 60 years of age, and one report[96] used 65 years of age to designate the older patients. Exclusion of these five articles had minimal effect on the summary statistics (15.8 percent versus 12.1 percent, $z = 4.98$, $P < 0.001$).

Additional evidence to support a relation between age and CPR success rate was derived from 15‖ articles that permitted further breakdown of the age group older than 70 years. The rate of successful resuscitation was 15 percent for patients younger than 70 years, 12.2 percent for patients aged 70 to 79 years, 10.2 percent for patients aged 80 to 89 years, and 0 percent among the 8 patients older than 89 years of age (Figure 1). Despite this strong negative correlation ($r = -0.82$), a significant P value for such a small group number ($df = n-2 = 2$) would require a biologically improbable negative correlation of -0.95.

*References 5-7, 9-14, 16, 18-20, 22-26, 28, 30, 31, 33, 34, 39-41, 44, 46, 48-50, 52, 53, 55, 56, 59-62, 64-67, 70-74, 77, 78, 80-82, 85, 88, 89, 91, 92, 95-103.

†References 15, 17, 21, 27, 29, 32, 35-38, 42, 43, 45, 47, 51, 54, 57, 58, 63, 68, 69, 75, 76, 79, 83, 84, 86, 87, 90, 93, 94.

‡References 15, 21, 35, 37, 43, 51, 69, 79, 87, 90, 93, 94.

§References 7, 24, 43, 56-58, 65, 68, 72, 75, 79, 83, 85, 89, 91, 93-95, 97, 98.

‖References 17, 22, 24, 28, 33, 48, 49, 54, 56, 63, 65, 76, 87, 89, 90.

Table 1. Comparison of Factors Influencing the Success Rates of Cardiopulmonary Resuscitation from Pooled Reports, 1960–1990.

Factor	No. of Reports	Successful Resuscitation Rate	Successful Resuscitation %	Odds Ratio	95% Confidence Interval	z	χ^2_c	P Value	References
Age, years	33					5.01		< 0.001	9, 13, 17, 21, 22, 24, 28, 30,†
< 70		597/3692	(16.2)	1.36	1.20–1.53				33, 35, 43, 47†-49, 54, 56, 58,
> 70		259/2093	(12.4)	0.74	0.65–0.83				62,† 63, 65,‡ 69, 71, 72, 76, 83,† 87,‡ 89,§ 90, 92, 96,‖ 101-103
Hospital	98						76.0	< 0.001	
Community		1056/5710	(18.5)						7, 18, 28, 33, 39, 40, 44, 46-49, 56, 59-61, 70-74, 80-82, 84, 92, 93, 98-100, 102, 103
Teaching		1938/14,245	(13.6)						5, 6, 9-17, 19-27, 29-32, 34-38, 41-43, 45, 50-55, 57, 58, 62-69, 75-79, 83, 85-91, 94-97, 101
Patient type	98						90.3	< 0.001	5§-7, 9-84,§ 85-103
Perioperative		133/423	(31.4)						
Nonoperative		2861/19,532	(14.6)						
Living status	2						3.6	0.06	10, 100
Independent		23/208	(11.1)						
Nonindependent		5/118	(4.2)						
Cardiac rhythm*	35						158.4	< 0.001	10, 13, 14, 18-21, 23, 24, 27,
VF/VT		346/1732	(20.0)						29, 30, 32, 33, 36, 40, 44, 47,
Other		135/1383	(9.8)						50, 54, 55, 58, 65, 67,§ 69-72,
EMD		7/106	(6.6)						74, 76, 87, 89, 90, 93, 94
Asystole		110/1759	(6.3)						

*VF/VT = ventricular fibrillation/ventricular tachycardia, EMD = electromechanical dissociation, asystole includes bradycardia.
†Used 60 years as cut-point.
‡Data from "unknown" group not included in total.
§Estimated data.
‖Used 65 years as cut-point.

Only two articles[83,94] examined the elderly patient's satisfaction with the resuscitation experience. The often quoted report by Fusgen and Summa[83] found that 7 (77.8 percent) of the 9 patients older than 60 years who survived CPR objected to their own resuscitation. In contrast, Bayer, et al.[94] noted that none of the 13 elderly patients who were followed-up after discharge expressed regrets about having been resuscitated.

Sex

A similar comparison of 18 reports* that allowed pooling of data by patient sex showed a slightly higher but not significant rate of successful CPR among women patients when compared with men patients (15.9 percent versus 14.7 percent; [women] odds ratio = 1.07; 95 percent confidence interval, 0.91 to 1.27; $z = 0.85$; $P = 0.40$).

*References 18, 26, 33, 36, 47, 49, 56, 63, 65, 71, 83, 89, 90, 93, 94, 96, 100, 103.

Teaching versus Community Hospitals

CPR performed in the community hospitals was more likely to be successful than in the teaching institutions (18.5 percent versus 13.6 percent) (Table 1). This favorable clinical outcome in community hospitals was statistically significant ($\chi^2_c = 76, P < 0.001$).

Perioperative versus Nonoperative Patients

When data from 98 reports[5-7,9-103] were pooled, we found a CPR success rate of 31.4 percent (133/423) among perioperative patients versus a 14.6 percent (2861/19,532) success rate among nonoperative patients ($\chi^2_c = 90.3$, $P < 0.001$) (Table 1).

Living Status before Cardiac Arrest

Only two reports[10,100] provided comparative data relative to the living status of the patient

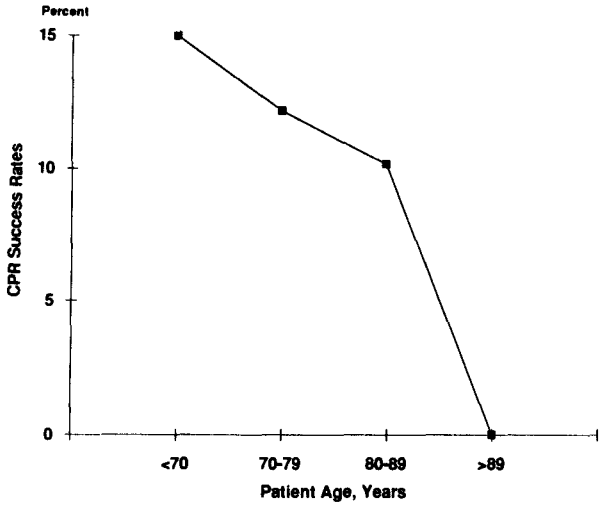

Figure 1. Pooled estimates of cardiopulmonary resuscitation (CPR) success rates among the elderly declined from 15 percent for patients younger than 70 years to 0 percent for those patients older than 89 years.

before the cardiac arrest. Patients who were independent showed a trend toward a better prognosis than those who were nonindependent (11.1 percent versus 4.2 percent, $\chi^2_c = 3.6$, $P = 0.06$, β error = 0.36, power to detect 50 percent difference = 0.13) (Table 1).

Cardiac Rhythm

Thirty-five reports provided data for cardiac rhythm. Patients with ventricular fibrillation or ventricular tachycardia had a CPR success rate of 20 percent (346/1732). This rate was significantly higher than the 7.8 percent (252/3248) success rate for all other rhythms combined ($\chi^2_c = 158.4$, $P < 0.001$). The rates of successful CPR were very similar in the asystole, electromechanical dissociation, and "other" groups; 6.3 percent (110/1759), 6.6 percent (7/106), and 9.8 percent (135/1383), respectively (Table 1).

Primary Diagnosis

Data were pooled from 54 reports relative to the patient's primary underlying diagnosis (Table 2). An attempt was made to classify the diagnoses in which CPR had a higher or lower than average rate of success. Three categories were identified: low success (< 7 percent survival rate), moderate success (7 percent to 26 percent survival rate), and high success (> 26 percent survival rate). The central nervous system disease subgroups of hemorrhage (brain stem, cerebral, or subarachnoid) and cerebral vascular accident had a low survival rate: 1.4 percent (1/69) and 4.3 percent (6/141), respectively. Only dissecting aneurysm had a success rate of zero (95 percent upper confidence interval, 13.3 percent) among the 21 patients. The moderate success category comprised pulmonary and cardiac diseases, and only shock rated in the high success category (29.4 percent, 5/17). Only five reports,[22,48,53,65,72] however, noted the diagnosis of shock, with one article[48] reporting a 100 percent (3/3) success rate. By pooling data from the remaining reports, we found a 14.3 percent (2/14) rate of successful resuscitation, making the result from Neufeld[48] suspect, as well as the listing of shock as the sole entity in the high success category ($\chi^2_c = 5.10$, $P = 0.02$).

Trends in Data

Overall Trends

There was a higher proportion of reports during the first decade (1960–1970) that contained data for perioperative patients. In the 1960s,

Table 2. Pooled Estimates of Cardiopulmonary Resuscitation Success Rates by Primary Diagnosis.*

Diagnosis	No. of Reports	Successful Resuscitation Rate	Successful Resuscitation Percent
Low success (< 7 %)			
Dissecting aneurysm	7	0/21	0.0
Sepsis	8	2/109	1.8
Central nervous system	23	16/466	3.4
Trauma	17	10/279	3.6
Uremia	12	9/203	4.4
Cancer	16	9/185	4.9
Pulmonary embolus	25	18/278	6.5
Moderate success (7%–26%)			
Pneumonia	8	9/109	8.3
Congestive heart failure	17	60/676	8.9
Pulmonary edema	4	4/31	12.9
COPD†	6	16/117	13.7
Pulmonary NOS†	20	60/416	14.4
Coronary artery disease	18	292/1979	14.8
Myocardial infarct	42	441/2921	15.1
Cardiovascular NOS†	25	87/420	20.7
High success (> 26%)			
Shock	5	5/17	29.4

*References 11,13-18, 21-23, 25-27, 30, 32-38, 40, 41, 43-45, 47-49, 51, 53-56, 58, 59, 63, 65, 67, 70-73, 75, 76, 79, 83, 84, 86, 89, 93, 94, 96, 100.

†COPD = chronic obstructive pulmonary disease, NOS = not otherwise specified.

Table 3. Outlier Reports — Cardiopulmonary Resuscitation Success Rates Exceeding 3 Standard Deviation Confidence Intervals, 4.0% to 26.2%.

Study	Year	Successful Resuscitation	
		Rate	Percent
Kouwenhoven, et al.[5]	1960	14/20	70.0
Shipman, et al.[14]	1962	10/30	33.3
Keevil, et al.[18]	1963	2/5	40.0
Jordan, et al.[23]	1964	3/100	3.0
Sandoval[28]	1965	8/26	30.8
Day[33]	1965	9/16	56.2
Gilston[35]	1965	13/37	35.1
Hansen and Sandoe[38]	1966	16/47	34.0
Arnfred, et al.[42]	1966	17/50	34.0
Linko, et al.[47]	1967	27 /100	27.0
Peschin and Coakley[64]	1970	28/734	3.8
Keenan and Boyan[96]	1985	13/27	48.2
Draur[101]	1989	53/126	42.1

18 (35.3 percent)* of 51 reports contained perioperative data compared with 2 (8 percent)[61,84] of 25 reports in the 1970s and 2 (9.1 percent)[96,99] of 22 reports in the 1980s ($r = -0.31$, $P < 0.001$).

With all 98 reports[5-7,9-103] considered, there was no significant relation between year of study and CPR success rate ($r = -0.14$, $P > 0.05$) (Figure 2). The exclusion of perioperative data reduced the correlation coefficient to −0.10; and with the exclusion of both perioperative data and the 13 reports identified as outliers (Table 3), the correlation coefficient approached zero (r = 0.05).

Outliers

Reports with higher than expected CPR success rates were generally explained by the inclusion (either predominantly or exclusively) of patients with a favorable location or diagnosis at the time of arrest (e.g., the 56.2 percent success rate reported in Day's study[33] was obtained from patients in a cardiac care unit). The two outliers on the lower end of the confidence interval, Jordan, et al.[23] and Peschin and Coakley,[64] remained unexplained (Table 3).

Optimism for CPR

Despite any detectable change in the CPR success rate during the past 30 years, optimism about the value of CPR has declined. Two authors (APS and DJN) reviewed the 98 reports[5-7,9-103] to determine whether each report's author(s) took an optimistic or pessimistic view regarding CPR outcome. In this subjective analysis, 47 (92.2 percent)† of the 51 reports published in the 1960s, 20 (80 percent)[61-65,67-77,79,81,82,85] of the 25 reports pulished in the 1970s, and only 15 (68.2 percent)‡ of the 22 reports published in the 1980s were judged optimistic ($r = -0.29$, $P < 0.01$) (Figure 3).

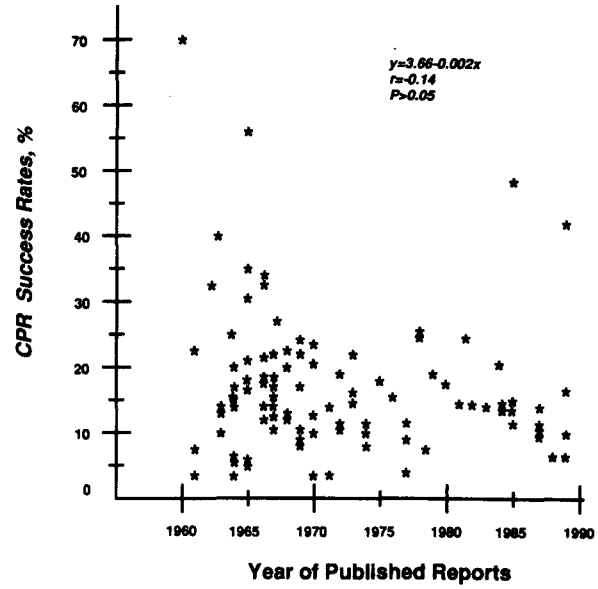

Figure 2. Cardiopulmonary resuscitation (CPR) success rates (survival-to-discharge) by year (1960 –1990) for 98 reports.[5-7,9-103] Perioperative patients were included. There was no significant trend in success rates.

Central Nervous System Assessment

It was hypothesized that concern regarding central nervous system complications as a result of CPR had increased in recent years. Somewhat surprising, however, was the finding of a declining proportion of articles during this 30-year period reporting post-CPR neurological status ($r = -0.20$, $P = 0.05$).[5-7,9-103]

Time and Place Issues

Location

Data about the relation between location of arrest and successful resuscitation were derived from 44 reports. There was a relation between the immediate availability of medical personnel and equipment and the probability of successful CPR (Table 4).

*References 5, 11-15, 19-21, 25, 35-37, 39, 43, 49, 53, 59.

†References 5, 11, 12, 14-19, 21-23, 26-60.

‡References 7, 86, 87, 89-94, 96, 97, 100, 101-103.

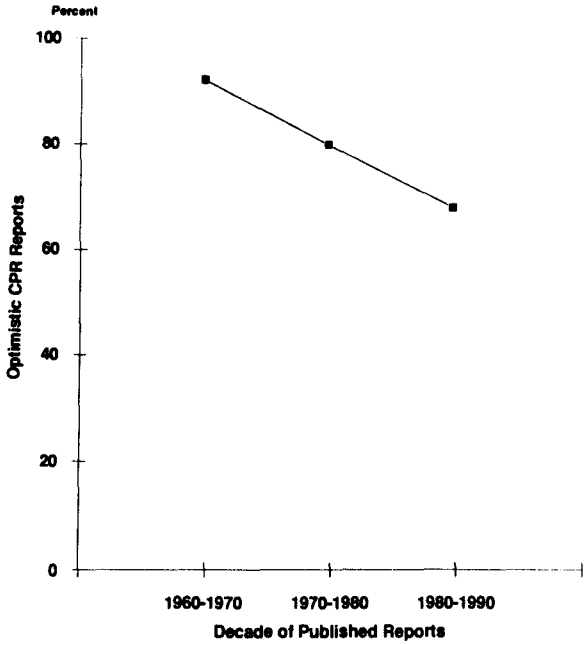

Figure 3. The proportion of reports, by decade, that were optimistic regarding the value of cardiopulmonary resuscitation (CPR) fell from 92.2 percent (47/51) in the 1960s to 68.2 percent (15/22) in the 1980s.

Duration

Pooled data from four reports[19,27,89,92] revealed a success rate of 28.8 percent (83/288) when the duration of CPR lasted less than 30 minutes compared with a 1.2 percent success rate (4/330) when the CPR attempts were longer than 30 minutes ($\chi^2_c = 94.6, P < 0.001$). A similar trend of a 35.1 percent (84/239) success rate for CPR attempts lasting less than 15 minutes versus 7.3 percent (40/549) for those attempts exceeding 15 minutes was noted from data pooled in five similar reports[47,84,89,92,100] ($\chi^2_c = 95.4, P < 0.001$). Peschin and Coakley[64] reported an average 26.8 minutes for each resuscitation attempt regardless of its outcome. Among the nearly 20,000 patients in this meta-analysis, 4 patients survived CPR following a prolonged resuscitation attempt (45 minutes, 50 minutes, 3.5 hours, and 3.5 hours, respectively).[30,42,58]

Hospital Day

Three reports[34,49,94] noted which hospital day that the arrest occurred. Roser[49] found that 46 (46.9 percent) of 98 arrests occurred on the first hospital day. In a surprisingly similar statistic, Bayer, et al.[94] reported 46 (48.4 percent) of 95 arrests occurring on the first day of hospitalization. Roser's data[49] also showed that 62.2 percent (61/98) of the arrests were within the first 2 days of hospitalization, and Nachlas and Miller[34] reported that 68.3 percent (41/60) of all arrests occurred on the first or second hospital day.

Complications and Cost

Autopsy Data

Fourteen reports,* all published in the 1960s, allowed pooling of data regarding autopsy outcome for 2 or more patients. Rib fracture was the most frequently reported complication (32.1 percent, 191/595), with marrow emboli (11.4 percent, 44/385), hemopericardium (5.1 percent, 20/389), and liver or spleen laceration (4.8 percent, 19/394) also noted.

Brain Damage

A review of the 66 reports† that provided data for neurological sequelae found central nervous system impairment to be present in 33 (1.6 per-

*References 11, 14, 18-20, 24, 25, 27-29, 36, 53, 54, 56.
†References 7, 12-20, 22-32, 34, 36, 37, 41, 43-50, 52-61, 63, 65, 67-69, 72-76, 78, 82, 84, 85, 87, 89, 90, 93-96, 98,100.

Table 4. Pooled Estimates of Cardiopulmonary Resuscitation Success Rates by Site of Arrest.*

Arrest Site	No. of Reports	Successful Resuscitation		95% Confidence Interval
		Rate	Percent	
Cardiac catheterization laboratory	3	11/15	73.3	51.0 to 95.7
Operating room	19	107/338	31.7	26.7 to 36.6
X-ray department	3	4/17	23.5	3.4 to 43.7
Locations NOS†	13	149/651	22.9	19.7 to 26.1
Emergency department	20	268/1174	22.8	20.4 to 25.2
Cardiac care unit	9	126/681	18.5	15.6 to 21.4
Intensive care unit	19	242/1620	14.9	13.2 to 16.7
Ward	27	364/3204	11.4	10.3 to 12.5

*References 7, 11-15, 18-21, 25, 32, 33, 36, 37, 39, 42, 43, 46, 47, 51, 53, 55, 56, 59, 61, 63, 65, 67, 69-72, 75, 76, 80, 84, 86, 88, 90, 94, 99, 100.
†NOS = not otherwise specified.

cent) of 2009 successfully resuscitated patients. The impairment was judged to be mild to moderate in 13 and severe in 15 of the 33 patients. The condition of the remaining 5 patients with central nervous system impairment could not be classified.[84]

Prolonged Hospitalization

The possibility of an extended post-CPR hospital stay (especially in a vegetative state) is a major concern to all. The pooling of available data revealed that 45.7 percent of the CPR patients not surviving to be discharged from the hospital (CPR failures) were dead within 24 hours, 72.9 percent within 72 hours, 85.6 percent within1 week, and 98.0 percent within 1 month (Table 5). Unfortunately, prolonged survival in the hospital did occur. Peatfield, et al.[79] reported 1 patient who lived 310 days in the hospital before dying.

Discussion

This review of in-hospital CPR during the last 3 decades found that 1 (15 percent) out of 6 or 7 patients undergoing CPR survives to be discharged from the hospital. Community hospitals have had a higher success rate than teaching hospitals (18.5 percent versus 13.6 percent). The primary underlying diagnoses for which a CPR success rate was less than 7 percent are listed in Table 2.

There was a decline in the likelihood of in-hospital CPR success with age (16.2 percent for < 70 years versus 12.4 percent for > 70 years). A similar difference in the success of out-of-hospital CPR among younger patients compared with elderly patients has been reported (14 percent for < 70 years versus 10 percent for ≥ 70 years).[110] The finding by Taffet, et al.[9] of a 0 percent (0/77) CPR success rate among elderly patients at the Veterans Administration Medical Center in Houston was extreme. The authors themselves noted that their findings were applicable to sick and aged men patients and would not apply to healthy ambulatory patients or certain elderly hospitalized patients.

The long-term survivorship among CPR patients was good to at least 36 months follow-up (44 percent). Data regarding CPR survival beyond 36 months, however, were sparse and contradictory. A similar statement can be made regarding the elderly patients' view on CPR.

Table 5. Pooled Estimates of Length of Postcardiopulmonary Resuscitation (CPR) Hospital Survival among Patients Initially Resuscitated but Dying before Discharge (CPR Failures).*

Status	No. of Reports	CPR Failure Rate	CPR Failure Percent
Dead within 24 hours	14	525/1148	45.7
Dead within 72 hours	5	137/188	72.9
Dead within 1 week	9	481/562	85.6
Dead within 1 month	7	494/504	98.0

*References 9, 13, 20, 26, 27, 30, 49, 56, 60, 65, 69, 76, 79, 84, 87, 89, 90, 94, 95.

Trends

Fewer perioperative patients were noted in reports published in more recent years, probably signifying a decreased risk of cardiac or respiratory arrest during surgery. The proportion of perioperative patients with a more favorable CPR prognosis has declined during the past 30 years. There was, however, no trend in CPR outcome during this 30-year period, with the CPR success rate remaining remarkably stable. The unreferenced assertion by Murphy, et al.[10] that CPR success rates have steadily declined was not supported by this review. The jury is still out on newer CPR techniques. Recent randomized clinical trials of glucocorticoids[111] and a calcium-entry blocker[112] failed to show improved neurological recovery following cardiac arrest. Similarly, a study of high-dose epinephrine versus routine-dose epinephrine[113] actually showed a lower survival rate in the high-dose group. A recent controlled trial,[114] however, of interposed abdominal counterpulsation versus conventional CPR did find a higher survival-to-discharge rate (25 percent versus 7 percent, $P = 0.02$).

Availability of Medical Personnel

The close proximity of medical personnel and equipment had an impact on the rate of successful resuscitation. The finding that nearly one-half of the arrests occurred on the first hospital day[49,94] and two-thirds of the arrests occurred before the third hospital day[34,49] should assist in the clinical decision regarding patient priority status in view of the increasingly frequent problem of limited monitored bed availability.

Location

The best resuscitation rates were found among perioperative patients and those patients in intensive care settings (Table 4). Nonetheless, the unreferenced comment by Lavie and Gersh[115] that "Treatment of primary ventricular fibrillation in patients in the coronary-care unit is almost invariably successful . . . " was not confirmed by the data in this review. Nor was the unreferenced comment by Lumley and Zideman[116] that " . . . cardiopulmonary collapse and its management in these fully monitored environments ['perioperative CPR'] does not have better short-term or long-term results than resuscitation carried out in other environments."

Duration

Sporadic reports of prolonged (up to 5 hours) successful CPR have been made.[117] Nonetheless, CPR attempts exceeding 15 minutes were seldom effective (7.3 percent), and CPR attempts lasting longer than 30 minutes were rarely successful (1.2 percent). Similarly, Quan, et al.,[118] from King County, Washington, reported no successes among the 20 pediatric submersion victims whose resuscitation attempts exceeded 25 minutes.

Risks

The risks associated with CPR included a high proportion of rib fractures (32.1 percent) and a potential for trauma to internal organs. Overall, there was about a 1.6 percent risk of permanent neurological sequelae in patients discharged following CPR.

Various objections to this type of pooled analysis or meta-analysis can be made. The pooled data contained varying definitions of CPR, and it was likely that in some cases only a respiratory arrest had occurred; some studies were limited to groups or subgroups with a higher or lower than average probability of CPR success; and none of the 98 reports[5-7,9-103] included in this meta-analysis were conducted in a randomized control manner. The validity of this collective review is supported by the expected findings relative to sex, cardiac rhythm, location of arrest, and duration of resuscitation. We believe this overview provides the best available estimates about the effectiveness and risks of CPR, as well as the identification of discrepancies and deficiencies in the CPR data.

The lingering question remains: what would the rate of successful CPR be in hospitals with a model program where current advanced cardiac life support certification is required for all physicians and nurses in critical care areas? This model program would also have guidelines for excluding those patients who are poor candidates for CPR.

Summary

Resuscitation medicine mirrors clinical general medicine in that there are seldom zeros or one hundreds in probability assessments. If these numbers do occur, they should be suspect and generally can be attributed to low numbers or special populations. Neither absolute certainty nor absolute futility was found in any CPR group or subgroup. Even the 0 percent CPR success rate among the 21 patients with dissecting aneurysm had an upper-bound 95 percent confidence interval of 13.6 percent.

Although the rate of successful in-hospital resuscitation has not changed in 30 years, CPR does save lives. CPR, however, appears inappropriate for some chronically debilitated patients, especially those who are quite elderly. The increasing pessimism regarding the value of CPR does not appear justified by this review. There is an ongoing professional and ethical responsibility for physicians and nurses, especially those working in critical care areas, to maintain current CPR certification — preferably advanced cardiac life support. In addition, all physicians will be asked at some point for their opinion about the appropriateness of CPR especially in light of the Patient Self-Determination Act of 1990, which requires that all hospitalized patients are made aware of their rights regarding end-of-life issues.[119] The results of this review and meta-analysis should be of assistance in the formulation of that important clinical opinion.

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