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 noted that “Although CPR was initially seen as a dramatic and lifesaving intervention, its promise has faded with experience.” Current debates now include the appropriateness and even futility of CPR, especially in the elderly.

In an authoritative and highly recommended review, Safar 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, 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. Murphy, et al. claimed that CPR success rates were “decreasing steadily” but provided no citations. Two recent reports noted low CPR success rates among elderly patients and suggested that age was a negative predictor of CPR outcome. An editorial 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.

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
A successful resuscitation was defined, for 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 \(^8\) 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 \(^7,9\) provided rates for 5-year survivorship, and their results differed markedly: Peatfield, et al. \(^9\) 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 \((z = 5.01, P < 0.001; \chi^2 = 26.08, df = 32, P > 0.05)\) (Table 1). Four of these reported \(\chi^2\) for those older than 70 years \((z = 5.01, P < 0.001; \chi^2 = 26.08, df = 32, P > 0.05)\) (Table 1). Four of these reports \(10,47,62,83\) used 60 years of age to designate the older group and subgroup comparisons.

Various statistical tests were employed in this review and meta-analysis. \(\chi^2\) and Yates’ continuity correction \(10\); \(z\) represents the Yusuuf, et al. \(^10\) adaptation of the Mantel and Haenszel method \(107,108\); \(\chi^2\) and Yates’ correction \(10\); \(z\) represents the Yusuuf, et al. \(^10\) adaptation of the Mantel and Haenszel method \(107,108\); \(\chi^2\) and Yates’ correction \(10\);

The coefficient of correlation \(10\). The customary value of a two-sided \(P \leq 0.05\) was used. Data were analyzed with Appleworks (version 3.0) \(10\) 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

\(\chi^2\) and Yates’ continuity correction \(10\); \(z\) represents the Yusuuf, et al. \(^10\) adaptation of the Mantel and Haenszel method \(107,108\); \(\chi^2\) and Yates’ correction \(10\).

\(\chi^2\) and Yates’ correction \(10\); \(z\) represents the Yusuuf, et al. \(^10\) adaptation of the Mantel and Haenszel method \(107,108\); \(\chi^2\) and Yates’ correction \(10\).

\(\chi^2\) and Yates’ correction \(10\);

\(\chi^2\) and Yates’ correction \(10\).
Table 1. Comparison of Factors Influencing the Success Rates of Cardiopulmonary Resuscitation from Pooled Reports, 1960–1990.

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Reports</th>
<th>Rate</th>
<th>%</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
<th>z</th>
<th>P Value</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 70</td>
<td>33</td>
<td>597/3692 (62.2)</td>
<td>1.36</td>
<td>1.20–1.53</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
<td>9, 13, 17, 21, 22, 24, 28, 30, 33, 35, 43, 47, 49, 54, 56, 58, 62, 63, 65, 69, 71, 72, 76, 83, 87, 89, 90, 92, 96, 101–103</td>
</tr>
<tr>
<td>&gt; 70</td>
<td></td>
<td>259/2093 (12.4)</td>
<td>0.74</td>
<td>0.65–0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Community</td>
<td>98</td>
<td>1056/5710 (18.5)</td>
<td></td>
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<tr>
<td>Teaching</td>
<td></td>
<td>1938/14,245 (13.6)</td>
<td></td>
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<td></td>
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<tr>
<td>Patient type</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perioperative</td>
<td>98</td>
<td>133/423 (31.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td></td>
<td>2861/19,532 (14.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>2</td>
<td>23/208 (11.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td>10, 100</td>
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<tr>
<td>Nonindependent</td>
<td></td>
<td>5/118 (4.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac rhythm*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF/VVT</td>
<td>35</td>
<td>346/1732 (20.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
<td>10, 13, 14, 18-21, 23, 24, 27, 29, 30, 32, 33, 36, 40, 44, 47, 50, 54, 55, 58, 65, 67, 69-72, 74, 76, 87, 89, 90, 93, 94</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>135/1383 (9.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMD</td>
<td></td>
<td>7/106 (6.6)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td></td>
<td>110/1759 (6.3)</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*V/F/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 articles83,94 examined the elderly patient’s satisfaction with the resuscitation experience. The often quoted report by Fusgen and Summa83 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).

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 ($x^2_c = 76, P < 0.001$).

Perioperative versus Nonoperative Patients
When data from 98 reports5-7,9-103 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 ($x^2_c = 90.3, P < 0.001$) (Table 1).

Living Status before Cardiac Arrest
Only two reports10,100 provided comparative data relative to the living status of the patient

*References 18, 26, 33, 36, 47, 49, 56, 63, 65, 71, 83, 89, 90, 93, 94, 96, 100, 103.
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, \( \chi^2_c = 3.6, P = 0.06, \beta \text{ error} = 0.36, \text{power to detect 50 percent difference} = 0.13 \) (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>
<thead>
<tr>
<th>Table 2. Pooled Estimates of Cardiopulmonary Resuscitation Success Rates by Primary Diagnosis.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Low success (&lt; 7 %)</td>
</tr>
<tr>
<td>Dissecting aneurysm</td>
</tr>
<tr>
<td>Sepsis</td>
</tr>
<tr>
<td>Central nervous system</td>
</tr>
<tr>
<td>Trauma</td>
</tr>
<tr>
<td>Uremia</td>
</tr>
<tr>
<td>Cancer</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
</tr>
<tr>
<td>Moderate success (7%–26%)</td>
</tr>
<tr>
<td>Pneumonia</td>
</tr>
<tr>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>Pulmonary edema</td>
</tr>
<tr>
<td>COPD</td>
</tr>
<tr>
<td>Pulmonary NOS(^1)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>Myocardial infarct</td>
</tr>
<tr>
<td>Cardiovascular NOS(^1)</td>
</tr>
<tr>
<td>High success (&gt; 26%)</td>
</tr>
<tr>
<td>Shock</td>
</tr>
</tbody>
</table>


\(^{1}\)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%.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Successful Resuscitation Rate Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kouwenhoven, et al. 5</td>
<td>1960</td>
<td>14/20 70.0</td>
</tr>
<tr>
<td>Shipman, et al. 14</td>
<td>1962</td>
<td>10/30 33.3</td>
</tr>
<tr>
<td>Keevil, et al. 18</td>
<td>1963</td>
<td>2/5 40.0</td>
</tr>
<tr>
<td>Jordan, et al. 23</td>
<td>1964</td>
<td>3/100 3.0</td>
</tr>
<tr>
<td>Sandoval 28</td>
<td>1965</td>
<td>8/26 30.8</td>
</tr>
<tr>
<td>Day 33</td>
<td>1965</td>
<td>9/16 56.2</td>
</tr>
<tr>
<td>Gilston 35</td>
<td>1965</td>
<td>13/37 35.1</td>
</tr>
<tr>
<td>Hansen and Sandoe 38</td>
<td>1966</td>
<td>16/47 34.0</td>
</tr>
<tr>
<td>Arnfred, et al. 42</td>
<td>1966</td>
<td>17/50 34.0</td>
</tr>
<tr>
<td>Linko, et al. 47</td>
<td>1967</td>
<td>27/100 27.0</td>
</tr>
<tr>
<td>Peschin and Coakley 64</td>
<td>1970</td>
<td>28/734 3.8</td>
</tr>
<tr>
<td>Keenan and Boyan 69</td>
<td>1985</td>
<td>13/27 48.2</td>
</tr>
<tr>
<td>Draur 101</td>
<td>1989</td>
<td>53/126 42.1</td>
</tr>
</tbody>
</table>

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)69,99 of 22 reports in the 1980s ($r = -0.31, P < 0.001$).

With all 98 reports5-7,9-103 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 study33 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 reports5-7,9-103 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)$^\dagger$ of the 51 reports published in the 1960s, 20 (80 percent)$^61-65,67-77,79,81,82,85$ of the 25 reports published in the 1970s, and only 15 (68.2 percent)$^8$ of the 22 reports published in the 1980s were judged optimistic ($r = -0.29, P < 0.01$) (Figure 3).

**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, 12, 14-19, 21-23, 26-60.

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

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

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

*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.

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).
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 within 1 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>
<thead>
<tr>
<th>Status</th>
<th>No. of Reports</th>
<th>Rate</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead within 24 hours</td>
<td>14</td>
<td>525/1148</td>
<td>45.7</td>
</tr>
<tr>
<td>Dead within 72 hours</td>
<td>5</td>
<td>137/188</td>
<td>72.9</td>
</tr>
<tr>
<td>Dead within 1 week</td>
<td>9</td>
<td>481/562</td>
<td>85.6</td>
</tr>
<tr>
<td>Dead within 1 month</td>
<td>7</td>
<td>494/504</td>
<td>98.0</td>
</tr>
</tbody>
</table>

*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 glucocorticoids111 and a calcium-entry blocker112 failed to show improved neurological recovery following cardiac arrest. Similarly, a study of high-dose epinephrine versus routine-dose epinephrine113 actually showed a lower survival rate in the high-dose group. A recent controlled trial, 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 day49,94 and two-thirds of the arrests occurred before the third hospital day34,49 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 un referenced comment by Lavie and Gersh\textsuperscript{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 un referenced comment by Lumley and Zideman\textsuperscript{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.\textsuperscript{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.,\textsuperscript{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\textsuperscript{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 sub-group. Even the 0 percent CPR success rate among the 21 patients with dissecting aneurysms 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.\textsuperscript{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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