Survey of 3765 cardiopulmonary resuscitations in British hospitals (the BRESUS study): methods and overall results

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Abstract

Objective—To determine the circumstances, incidence, and outcome of cardiopulmonary resuscitation in British hospitals.

Design—Hospitals registered all cardiopulmonary resuscitation attempts for 12 months or longer and followed survival to one year.

Setting—12 metropolitan, provincial, teaching, and non-teaching hospitals across Britain.

Subjects—3765 patients in whom a resuscitation attempt was performed, including 927 in whom the onset of arrest was outside the hospital.

Main outcome measure—Survival after initial resuscitation, at 24 hours, at discharge from hospital, and at one year, calculated by the life table method.

Results—There were 417 known survivors at one year, with 214 lost to follow up. By life table analysis for every eight attempted resuscitations there were three immediate survivors, two at 24 hours, 1.5 leaving hospital alive, and one alive at one year. Survival at one year was 12.5% including out of hospital cases and 15.0% not including these cases. Each hospital year averaged 30 survivors at one year: three who had an arrest outside hospital, seven who had one in the accident and emergency department, seven in the cardiac care unit, 10 in the general wards, and three in other, non-ward areas. Within the hospitals survival rates were best in those who had an arrest in the accident and emergency department, the cardiac care unit, or other specialised units. Outcome varied 12-fold in subgroups defined by age, type of arrest, and place of arrest.

Conclusion—71% of the mortality at one year in patients undergoing attempted resuscitation occurred during the initial arrest. Hospital resuscitation is life saving and cost effective and warrants appropriate attention, training, coordination, and equipment.

Introduction

The United Kingdom Resuscitation Council was established in 1982 to foster improved knowledge and practice of cardiopulmonary resuscitation. At this time the subject was comparatively neglected in Britain compared with the United States.^{1,2} As part of a wider programme^{3,5} the council organised a multicentre study of the circumstances, incidence, and outcome of cardiopulmonary resuscitation in hospital aimed at determining what is happening in a part of hospital practice not covered by routine statistics; developing a standard method of recording arrests that could be used for audit, clinical trials, and, possibly, community studies; and providing a British baseline against which results from other countries, changing management, and future surveys could be assessed.⁶ This first paper describes the methods and overall results, with survival followed to one year. Detailed analysis of subgroups will be reported elsewhere.

Methods

ORGANISATION

The 12 hospitals registered arrests for a year or more. Follow up was for one year. Each hospital's

coordinator initiated a logging system, supplementing hospital switchboard records with active monitoring of hospital areas not using emergency calls.

The target was to record all cases of attempted cardiopulmonary resuscitation started in hospital or continued on arrival with the subsequent exclusion of false alarms or recurrences within 24 hours. A designated member of the resuscitation team was responsible for completing the primary record form during the arrest and recorded information up to the dispersal of the team. The hospital coordinator completed a secondary record, with follow up to discharge or six weeks, and forwarded log, primary, and secondary records to Brighton. A tertiary record form took follow up to one year through the general practitioner.

CONTENT

The primary form recorded the circumstances of the arrest, evidence for the kind of arrest, interventions, composition of the team, outcome of the resuscitation attempt, and judgments on the appropriateness of the attempt and problems encountered. The secondary record concerned the patient's condition at 24 hours and at discharge (or six weeks) with any revised diagnosis. The tertiary record showed survival and condition at one year.

SURVIVAL

Survival was calculated by the life table method to allow for losses to follow up and is presented as percentage survival through four single and two composite time periods. The single periods were: (1) through the arrest; (2) from the arrest to 24 hours; (3) from 24 hours to discharge or six weeks; and (4) from discharge or six weeks to one year. The probability of survival through more than one period is the multiple of the individual probabilities. The two chosen combinations were: 2.4 (that is, $2 \times 3 \times 4$)—survival to one year after successful resuscitation—and 1.4 (that is, $1 \times 2 \times 3 \times 4$)—survival to one year from the onset of the arrest.

As this is a descriptive study with multiple comparisons formal statistical tests were kept to a minimum. Numbers were great enough in the larger groups to show highly significant differences in survival.

Results

NUMBERS OF HOSPITALS AND EVENTS

Hospitals were recruited serially after pilot testing. The returns of the hospital recruited first ran from January 1985 and those of that recruited last from November 1985. Eight hospitals (table I) exceeded the one year minimum follow up, so the study covers 15.5 hospital years and 3765 arrests. These averaged 243 a hospital year, or just over 20 in each hospital each month (range 12–33). The number correlates better with an index of turnover—admissions to the cardiac care unit—than with the reported number of acute beds (which may not be consistently defined).

SURVIVAL BY AGE AND SEX

A total of 417 survivors of the 3765 resuscitation

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attempts were identified at one year. In all, 214 were lost to follow up: 110 were not traced beyond the resuscitation; outcome was not known after 24 hours in 20; and of 623 alive at discharge, 84 were not traced.

By using life table analysis, to allow for missing data, survival through the resuscitation was 38.7%. In all, 71.7% of these initial survivors lived to 24 hours; of these, 62.7% lived to hospital discharge or six weeks, and 71.8% of these patients lived to one year. The proportion of initial survivors who lived to one year was therefore 32.4%, and survival through resuscitation to one year was 12.5%.

Table II shows results by sex and age. Survival was similar in men and women at each follow up when all

ages are combined and generally similar in each age group, but men who had an arrest outnumbered women who had one by almost two to one, except beyond the age of 85. Lower survival rates in elderly people resulted from a lower initial success rate and also a higher attrition rate thereafter, which was greater before discharge than after. The initial success rate was near 30% in people above 75 years, but survival at one year was below 10%; in contrast 20% of people aged 25-44 survived to one year.

PLACE OF ARREST

Table III gives results by place of onset of the arrest. Patients in whom resuscitation was initiated outside hospital and continued on arrival had only 40% of the study average survival at one year. Their initial survival was half the study average, and there was also greater attrition after 24 hours. Patients who had an arrest in the accident and emergency department were similar in terms of number and survival to those who had one in the cardiac care unit, and, like those who had one in specialised non-ward areas, had an initial survival rate near 50% and a one year survival near 20%. However, half of the arrests in hospital occurred in patients on general wards, and survival was lower at each stage, during the arrest and subsequently, yielding a one year survival of 11%. Analysis of cases occurring in hospital alone by sex and age group shows a pattern similar to that in table II but with improved survival—dramatically so in children, where out of hospital cases accounted for most deaths and there were no survivors.

TABLE I—Participating hospitals, length of participation, and numbers of acute beds, cardiac care unit admissions, and resuscitation attempts during study

Hospital	No of months in study	No of acute beds	No of cardiac care unit admissions	No of resuscitation attempts
Royal Sussex County	26	378	1 537	702
Hammersmith, London	17	632	413	211
Ninewells, Dundee	22	784	951	297
Leicester Royal Infirmary	14	850	966	297
Edgware General, London	13	348	806	244
Frenchay, Bristol	12	568	300	194
Northampton General	12	551	917	205
Royal Victoria Infirmary, Newcastle	14	583	525	248
Royal Free, London	18	720	750	457
Stockport and Stepping Hill	12	750	1 224	215
Edinburgh Royal Infirmary	12	800	1 400	394
Southend	14	630	642	301
Total	186	7705	10 431	3765

TABLE II—Numbers of cases, losses to follow up, and survivors at one year and percentage survival through each stage, by sex and age group

Age group (years)	No of cases	No lost to follow up	No alive at 1 year	Percentage survival					
				Through arrest	From arrest to 24 h	From 24 h to discharge	From discharge to 1 year	From arrest to 1 year	Through arrest to 1 year
Men									
0-14	48	2	8	27	88	91	84	67	18
-24	37	2	4	27	63	83	89	47	13
-34	48	5	7	38	89	77	70	48	18
-44	91	8	20	47	84	80	78	53	25
-54	240	20	49	47	75	76	88	50	23
-64	571	34	74	42	76	68	66	34	14
-74	745	29	67	39	71	52	68	25	10
-84	428	21	33	36	67	56	63	24	9
≥85	64	2	3	33	54	48	60	15	5
Not known	145	6	6	21	86	42	67	24	5
Total	2417	129	271	38.5	73.1	62.6	71.0	32.5	12.5
Women									
0-14	36	3	5	28	74	92	91	62	17
-24	16	4	2	44	77	89	67	46	20
-34	28	2	5	61	85	43	91	33	20
-44	47	4	8	43	68	72	94	46	20
-54	84	6	12	49	76	50	89	34	16
-64	248	23	39	47	79	72	69	39	18
-74	392	22	42	42	65	64	68	29	12
-84	358	14	23	31	61	54	70	23	7
≥85	77	3	5	26	74	57	67	28	7
Not known	62	4	5	31	47	63	100	29	9
Total	1348	85	146	39.0	69.0	62.9	73.2	31.8	12.4
Overall total	3765	214	417	38.7	71.7	62.7	71.8	32.4	12.5

TABLE III—Survival by place of onset of arrest

Place of onset	No of cases	No lost to follow up	No alive at 1 year	Percentage survival					
				Through arrest	From arrest to 24 h	From 24 h to discharge	From discharge to 1 year	From arrest to 1 year	Through arrest to 1 year
Outside hospital (915 cases) or unspecified (12 cases)	927	24	41	20	74	53	64	25	5
Inside hospital (all locations)	2838	190	376	45	71	64	73	33	15
Accident and emergency department	580	44	97	49	72	68	79	39	19
Cardiac care unit	612	34	108	49	74	70	77	40	19
Intensive care unit, theatres, investigation rooms	143	14	21	52	76	56	78	33	17
Other hospital (non-ward) areas	116	11	21	50	73	78	72	41	21
General wards	1387	87	129	40	69	58	65	26	11

TABLE IV—Survival by attending doctor's report as to whether arrest was cardiac or respiratory or both

Type of arrest	No of cases	No lost to follow up	No alive at 1 year	Percentage survival					
				Through arrest	From arrest to 24 h	From 24 h to discharge	From discharge to 1 year	From arrest to 1 year	Through arrest to 1 year
Cardiac	2103	126	272	41	75	65	72	35	14
Respiratory	421	46	65	60	69	61	73	31	18
Both cardiac and respiratory	694	24	42	27	66	53	72	25	7
Other	99	7	14	52	67	65	72	31	16
No information	54	3	4	44	60	44	73	19	9
Not known	394	8	20	18	68	62	71	30	5

TABLE V—Survival by place of onset of arrest, type of arrest, and age

	No of cases	No lost to follow up	No alive at 1 year	Percentage survival					
				Through arrest	From arrest to 24 h	From 24 h to discharge	From discharge to 1 year	From arrest to 1 year	Through arrest to 1 year
Out of hospital, cardiac arrest:									
<65	194	8	15	26	84	62	65	34	9
≥65	259	3	12	24	70	49	57	20	5
Out of hospital, arrests other than cardiac:									
<65	237	7	9	16	68	57	72	28	5
≥65	237	6	5	15	70	36	67	17	2
General wards, cardiac arrest:									
<65	192	19	26	47	73	66	69	33	16
≥65	516	24	35	35	69	55	56	21	8
General wards, arrests other than cardiac:									
<65	259	19	35	53	68	57	76	30	16
≥65	420	25	33	36	66	59	63	25	9
Specialised hospital areas, cardiac arrest:									
<65	395	44	106	57	85	81	78	54	31
≥65	547	28	78	48	70	60	77	33	16
Specialised hospital areas, arrests other than cardiac:									
<65	217	16	42	49	76	76	76	44	22
≥65	292	15	21	40	57	47	75	20	8

TABLE VI—Survival by number of defibrillations

No of shocks	No of cases	No lost to follow up	No alive at 1 year	Percentage of survival					
				Through arrest	From arrest to 24 h	From 24 h to discharge	From discharge to 1 year	From arrest to 1 year	Through arrest to 1 year
0	1987	112	169	38	64	59	68	26	10
1	566	45	124	54	79	71	79	45	24
2	393	20	51	42	79	66	65	34	14
3	277	9	35	34	82	62	78	40	14
4	194	12	11	29	75	47	69	24	8
5	76	5	9	28	87	77	75	50	14
6	89	4	4	18	64	89	62	35	6
7-9	80	1	4	23	86	33	80	23	5
≥10	51	3	3	25	88	50	60	26	7
Not known	52	3	7	37	76	64	88	43	16

MODE OF ARREST

The initial record form asked if the arrest fell into the categories of primarily cardiac, primarily respiratory, both, other, or not known. Table IV shows that 56% of arrests were classified as primarily cardiac, 11% as respiratory, and 18% as both, with the remainder indeterminate. People who had arrests categorised as both cardiac and respiratory had a poor initial and subsequent survival rate. Those who had a cardiac arrest and those who had a respiratory arrest had a similar one year survival; those with cardiac arrests had a poorer initial survival but a safer subsequent hospital course. Prognosis from discharge to one year was the same for both types of arrest.

RISK GROUPS

Table V gives results for three places of onset (outside hospital, general hospital wards, and other hospital areas from table III), two modes of arrest (primarily cardiac and all other categories, including unknown), and two age groups (below 65 and 65 and above).

People below age 65 who had a cardiac arrest in specialised hospital areas—predominantly accident and emergency departments and cardiac care units—had an initial success rate of 57% and a one year survival rate of 31%, much better than the study

average. These accounted for only 14% of arrests occurring in hospital and 10% of all arrests and comprise the one good risk category, whereas seven groups had a one year survival below 10%. The three simple descriptors together give a four to one gradient in survival at one year for arrests in hospital, and a 12 to one gradient overall ($\chi^2=166$, $df=11$, $p<0.0001$), and each operates across subgroups, except that those having cardiac arrests fared as badly as those having other arrests on the general hospital wards.

MEDICAL CARE

The incidence and outcome of arrests did not vary appreciably by day of the week. Outcome in patients whose arrest was witnessed was better than in those found in the arrest (immediate survival 48% *v* 32%). Classification as to whether arrests were unexpected, considered likely, or complications of surgical or medical procedures showed little difference in outcome.

Survival decreased with increasing numbers of defibrillations from one (table VI), but much of this difference in one year mortality occurred during the arrest. There was some decline in survival after arrest in people who received more than six shocks, but the overall gradient is not steep.

Analysis of size of the arrest team showed a modal

value of six members, but there were eight or more present during one third of arrests. The best outcomes were in the small proportion of arrests managed by two or three people. Survival in each of the three hospital time periods decreased with increasing numbers involved in the resuscitation attempt, even though they were present only in the first period, but there was no difference after discharge.

Discussion

UNDER AND OVERREPORTING OF EVENTS

Some resuscitation attempts were probably missed, unlogged, and unreported, or logged without a matching form. Hospital coordinators found on inquiry that most of those logged without a form were false alarms, but some simply could not be traced. On the other hand, arrest calls were made for collapsed patients whose disease was varied. A search of 263 forms which recorded no defibrillation, no cardiac compression, and no pacing showed that almost all were genuine arrests—respiratory arrests where ventilation, intubation, or other interventions restored respiration, or cardiac arrests that reverted spontaneously or after a precordial thump—or narrative showed that the coding was wrong. Probably more genuine arrests were missed than false ones included, but these were impossible to quantify.

REPRESENTATIVES OF THE RESULTS

The average hospital had 30 one year survivors each year: three had had an arrest outside hospital; seven had one in the accident and emergency department; seven in the cardiac care unit; 10 in the general wards; 1.5 in intensive care, theatres, or investigation rooms; and 1.5 in other hospital, non-ward areas. For each one year survivor there were eight attempted resuscitations, three initial survivors, about two surviving the first 24 hours, and 1.5 leaving hospital alive.

These results should be typical of British hospitals but this is arguable both because the participating hospitals varied and because they were not chosen at random. Participation involved commitment and co-ordination which some potential recruits found they could not deliver. None the less our list included metropolitan, provincial, and teaching and non-teaching hospitals.

Comparison of results between hospitals and case series is jeopardised by different selective biases: age and case mix, the choice of whether some or all patients are subjected to attempted resuscitation, and criteria for deciding which cases are included. This report concerns all cases of suspected cardiac or respiratory arrest, including those whose documentation was incomplete, to give a comprehensive picture. Later reports will feature subgroups defined more restrictively for specific analyses.

The difficulties of comparing results in resuscitation studies, particularly for resuscitation attempts made outside of hospital, have led to a recent call for uniform criteria for recording and reporting data.⁷ These criteria cannot be applied retrospectively to published work on resuscitation in hospital, which comes predominantly from teaching hospitals,⁸⁻¹³ with a few studies in non-teaching hospitals,¹⁴⁻¹⁶ studies in accident and emergency departments,¹⁷⁻¹⁹ a review of the first 25 years,²⁰ and another large national survey from Belgium, albeit with a main emphasis on out of hospital resuscitation.²¹

Survival in our study is in line with these reports. The Belgian study reported an initial success rate of 34% and a success rate of 18% at two weeks.²¹ McGrath reviewed 12 961 patients in 42 papers and reported an average survival rate of 38.5% at 24 hours (range 13-59%) and 14.6% at discharge (range 3-27%),²⁰ while DeBard's earlier review quotes figures of 39% and at

discharge home of 17%.⁹ Our figures show an immediate survival of 39%, a survival of 28% at 24 hours, 17% at discharge home, and 12.5% at one year; if arrests that occurred out of hospital are excluded the results are 45%, 32%, 21%, and 15% respectively.

RISK FACTORS

Age (table II) and the place of arrest (table III) affected survival. Earlier studies implied that age does not affect survival after arrest,⁸ and that location does not influence immediate outcome,^{9,12} but the larger numbers in our study show these effects to be both immediate and delayed, as well as confirming good results from onset of arrest in accident and emergency departments.^{9,17-19} The results suggest that combined cardiac and respiratory arrest is more deadly than either alone. As these do not occur simultaneously this may be more an indication of time before help arrived than of primary disease. In combination (table V) the three variables—age, place of arrest, and type of arrest—define subgroups with major differences in survival rates, but none in which rates are so bad as to preclude resuscitation, unlike in other studies which report no survivors over age 70,¹⁶ or among out of hospital cases brought into hospital.²²

Resuscitation may reverse the arrest and its acute precipitants, but advanced age and underlying chronic disease may lead to a poor prognosis, especially in general hospital wards.^{13,14} However, if after one year seven lives out of eight are lost, these figures show that five of the seven people die during the index arrest. The greatest potential for improving long term survival may be in increasing the initial survival rates.

The estimates of time delays in resuscitation reported to us have not been analysed here, but our results suggest that speed and competence of response and duration of episode contribute to initial survival. Patients whose arrests are witnessed, are known to be primarily cardiac or respiratory, and occur in high surveillance areas have the best prognosis. Declining survival with the size of the resuscitation team and the number of defibrillations suggest that prolonged resuscitation has a poorer outcome. It takes time for a resuscitation team of more than six to congregate—this is more likely to be necessary in difficult cases. The number of defibrillations is related to duration of the arrest but also to the persistence or recurrence of ventricular fibrillation as distinct from ventricular asystole. Table VI suggests that the initial survivors of multiple shocks do as well or better than those who have none at all. Analyses of specific rhythms will be reported elsewhere.

IMPLICATIONS FOR RESUSCITATION MANAGEMENT

Since this study was initiated in the mid-1980s there have been developments which promise better results in the future. Widespread deployment of ambulances with trained staff and defibrillators is changing the potential for resuscitation out of hospital.²³ Increasing awareness of remediable deficiencies in the training of hospital staff²⁴⁻²⁷ led the Resuscitation Council to promote British (and potentially European) guidelines for standardising resuscitation procedures and hospital training.^{3,5} Following the recommendations of the Royal College of Physicians, hospitals are setting up resuscitation committees, appointing resuscitation training officers, and auditing their results by using simplified record forms derived from this study.²⁸ Compared with other life saving interventions hospital resuscitation is seen to be cost effective and a procedure where improved speed of reaction, training, and competence should produce improved results.

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Measuring the heights of very young children

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Pooled SDs of single height
measurements (SDshM) by age
group

Age group	SDshM (cm)
19-23 months	0.55
3 years	0.23
4-11 years	0.23

There are no published data on the reliability of measuring height in very young children. We investigated the accuracy and reproducibility of various height measuring instruments,¹ finding that the Harpenden stadiometer was no more reliable than the cheaper Raven minimetre.¹ We examine the reproducibility of height measurement in very young children aged 18 months to 2 years and in children aged 3 years, comparing these results with those reported in older children.¹

Subjects, methods, and results

Twenty seven children aged 19-23 months and 25 children aged from 2 years 10 months to 3 years 8 months attended their local community health clinic. Of the 27 youngest children, eight were crying or struggling while being measured, and the variance of their measurements was slightly higher than that of the other children in the group, but not significantly so ($p=0.072$). Their results were included in the analysis.

A Raven minimetre was used to measure the children. Two experienced auxologists measured each child twice in separated measurements. In addition, the mothers ensured that the children's heels were on the floor. For each measurer and group the SD of a single height measurement was calculated.¹

In the three age groups (19-23 months, 3 years, 4-11 years) there was no significant difference between the two measurers in the SD of a single height measurement

($p=0.15$, 0.92 , 0.54 respectively). Consequently, values were pooled (table). The SD of a single height measurement in children aged 4-11 years (0.23 cm) had been obtained by the same two measurers.¹ The value in the 3 year olds in this study (0.23 cm) was identical, while that in the youngest group was more than twice as large. Although two observers may measure with similar precision, they may none the less use different measuring techniques that result in different mean heights in the same children.¹ Using the minimetre, we found a (highly) significant difference between the mean heights obtained by the two observers for the youngest children (83.5 cm and 84.1 cm, $p<0.001$).

Comment

Height measurement with the Raven minimetre is no less reproducible than with the Harpenden stadiometer,¹ and the minimetre could, therefore, be used in a community setting by a trained health worker. Struggling children did not significantly increase the error of measurement when a correct technique for measuring was used.

The standard charts available are based on measurements of length up to the age of 2 years and of height thereafter.² In children aged between 18 and 20 months we found that there may be a mean decrease of 2 cm when changing from the supine (length) to the standing (height) position (unpublished data). We therefore recommend that a child's height, rather than length, be measured once a child can stand.

This study has shown that the SD of a single height measurement obtained by two experienced observers in 3 year old children was comparable with that obtained in older children. That the SD is larger for the youngest children (aged 19-23 months) should not be surprising nor preclude measurement. The spread of height velocity is greater at the age of 2 years than at