Epidemiology of out of hospital cardiac arrest – how to improve survival

Prof Gavin Perkins
Co-Chair ILCOR
Chair, Community Resuscitation Committee, Resuscitation Council (UK)
Conflict of interest

• Commercial – nil

• Academic
  – National Institute for Health Research funding to conduct clinical trials in cardiac arrest
  – BHF / RCUK support for OHCAO registry
  – Co-Chair ILCOR
  – BLS/AED roles (ILCOR, ERC, RCUK)
  – Editor Resuscitation
Outline

- National Out of Hospital Cardiac Arrest Registry
- Epidemiology of cardiac arrest
- Chain of survival
- System approaches to improving survival from cardiac arrest
- Research, audit and quality improvement
National Out of Hospital Cardiac Arrest Outcomes Project

BMJ Open
The UK Out of Hospital Cardiac Arrest Outcome (OHCAO) project

Geoff D Perkins, Samantha J BrACE-McDonald, On behalf of the OHCAO Project Group

Aim: The aim of the study was to estimate the magnitude and causes of death in OHCAO patients with out-of-hospital cardiac arrest in the UK. The study was conducted in collaboration with the National Out of Hospital Cardiac Arrest Outcomes Project (OHCAO).

Methods: This was a retrospective case-control study conducted in six UK ambulance services. The study population included all patients with out-of-hospital cardiac arrest who were transported to hospital between 1 January 2008 and 31 December 2010. The outcome measures were survival to discharge and survival to hospital discharge. The primary outcome measure was survival to hospital discharge.

Results: A total of 55,000 eligible patients were identified. The overall survival to hospital discharge rate was 14.5% (95% CI 13.9-15.1). The survival rate varied significantly between regions, with the lowest survival rate in the North West region (11.4% CI 10.8-12.1) and the highest survival rate in the South West region (17.3% CI 16.7-18.0). The most common causes of death were cardiac arrest (44.6%, 95% CI 43.3-46.0) and non-cardiac causes (33.8%, 95% CI 32.8-34.8).

Conclusion: The OHCAO study provides valuable insights into the outcomes of OHCAO patients in the UK. The results highlight the need for targeted interventions to improve survival rates and reduce the burden of out-of-hospital cardiac arrest in the UK.
YOU CAN'T IMPROVE WHAT YOU DON'T MEASURE.
ILCOR Consensus Statement

Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest

Perkins GD, Jacobs J, Nadkarni V et al 2015
Epidemiology Report

Report for the period January - December 2015, for the West Midlands Ambulance Service NHS Foundation Trust

Foreword

When the Department of Health published its Cardiovascular Disease Outcomes Strategy in 2013 it included the aspiration of saving 1,200 additional lives each year for those suffering from out of hospital cardiac arrest (OHCA).

One of the key steps in achieving that goal has been to establish a better understanding of the epidemiology, pathways of care and outcomes following OHCA.

We commend the initiative shown by the National Association of Ambulance Medical Directors for their vision in supporting the establishment of a national registry for OHCA, and acknowledge the support of the Resuscitation Council (UK), British Heart Foundation and University of Warwick in realizing this. Progress made over the last 3 years has enabled this document, the 2nd epidemiology and outcomes report for England, to be published.

The information in this report provides important insights into the epidemiology and outcomes of cardiac arrest in each region. Findings should be shared with Ambulance Trust Boards, commissioners and patient and public partners. Scrutiny of these data will assist the development of quality improvement initiatives to optimise the “Chain of Survival”.

Nationally, the Community Resuscitation Steering Group – a collective of stakeholder organisations has helped support best practice and is set to launch a consensus document “Resuscitation to Recovery: A National Framework to improve the care of people with Out-of-Hospital Cardiac Arrest in England”. The OHCAO registry is positioned to play a key role in evaluating the success of many collective efforts, and the continuing support of all those involved is commended and appreciated.

Together we can make a difference.

Professor Huw Gray,
National Clinical Director for Heart Disease, NHS England

Professor Jonathan Berger,
National Clinical Director for Urgent Care, NHS England

Figure 11: Arrival time of Emergency Medical Services to OHCA events in 2015.

Studies have shown that the chances of survival decrease significantly the longer it takes the EMS to arrive at the location of the OHCA. Ambulance response times have long been known to be independently associated with defibrillation and survival in OHCA (Paul et al., 2011) and the recommended response time is 5 minutes. In the UK, a study of the effect of reducing ambulance response times (ART) Poil and colleagues observed that a reduction in the 95th percentile ART from 15 to 5 minutes resulted in an 8% increase in the number of potential survivors. Reducing ART to 5 minutes was observed to almost double the survival rate for cardiac arrests not witnessed by ambulance crews.

Figure 11 presents details of the arrival time of EMS personnel to OHCA in WMAS. For any cardiac arrest that was first witnessed by EMS personnel the arrival time was changed to 0 minutes. About 50% of all non-EMS witnessed OHCA were reached in under 5 minutes. After 6 minutes there was an exponential decline in the proportion of cases with arrival time, however, approximately 2% of the cases were still not reached after 10 minutes. The reason for this latter is unknown. These could include cases where cardiac arrest was not recognised at the time of the emergency call leading to a lower response category. It is possible that it includes patients who sustained a cardiac arrest after the initial 999 call was made. Just under 60% of all OHCA incidents were reached in under 5 minutes, with a further 20.3% witnessed at the scene. Approximately 16.3% of cases were reached between 6 and 10 minutes. The corresponding figures for 2014 were 20.0%, 51.0% and 25.3%. We therefore observe an improvement in the proportion of OHCA cases that are reached in the recommended time.
Prediction of Out-of-Hospital Cardiac Arrest in England

Word count: 2,999

Introduction

Out-of-hospital cardiac arrest (OHCA) is a leading cause of cardiac related death in developed countries with only 7.6% of patients surviving to hospital discharge. However, in recent years several countries and regions have made major advances in the improvement of survival rates from OHCA: 25% patients in Stavanger, Norway survived to hospital discharge and 21% in Seattle and Northern Netherlands.

In England, approximately 30,000 cases are treated annually by emergency medical services (EMS). However, survival outcomes, including return of spontaneous circulation (ROSC) at hospital transfer and survival to hospital discharge, have achieved limited progress. Recent data from England ambulance services indicate that one in four patients can achieve ROSC at hospital transfer, while the survival to hospital discharge rate is still around 8%, with regional variation reported between 2%-12%.

Improving the management of OHCA is part of the Department of Health’s Cardiovascular Disease Outcomes strategy and the British Heart Foundation (BHF). Resuscitation Council UK (BRCUK) and NHS England are committed to improving OHCA survival outcomes in England.

Recent studies have recognized a range of case-mix and process factors in non-UK populations that are associated with OHCA survival outcomes. These include: location of OHCA, patient age and gender, bystander cardiopulmonary resuscitation (CPR), initial cardiac arrest rhythm, patient ethnicity, public access defibrillator (PAD) use and EMS response time.

The relative contribution of each of these factors to survival varies according to the situation and from country-to-country. In addition, only a few studies have assessed the

Model validation

The performance of the predictive models of both survival outcomes were shown in Table 5. Calibration, discrimination and overall performance were reduced in the validation data for both models. The hospital survival model outperformed the ROSC model regarding AUC and Brier’s score. The AUC values showed that the hospital survival model produced fair prediction while the ROSC model was less well predictive. The Cox calibration regression produced a positive intercept with an overall positive 95% confidence interval for the ROSC model, which indicated significant global under-prediction. The calibration plots in Figure 1 showed deviation from the diagonal line for the ROSC model. Concentration of observed probabilities in the lower tail for the survival to hospital transfer model also reflected poorer calibration in the validation data for both models.

Table 5: Performance of prediction models in the development and validation data

<table>
<thead>
<tr>
<th>Model Performance</th>
<th>Development</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC at hospital transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUC (95% CI)</td>
<td>0.646 (0.636, 0.666)</td>
<td>0.614 (0.604, 0.624)</td>
</tr>
<tr>
<td>Intercept (95% CI)</td>
<td>0.000 (-0.092, 0.106)</td>
<td>0.110 (0.096, 0.243)</td>
</tr>
<tr>
<td>Slope (95% CI)</td>
<td>1.006 (0.920, 1.096)</td>
<td>1.020 (0.979, 1.060)</td>
</tr>
<tr>
<td>Hosmer-Lemeshow test</td>
<td>10.2 (0.254)</td>
<td>6.89 (0.001)</td>
</tr>
<tr>
<td>Brier’s score</td>
<td>0.180</td>
<td>0.197</td>
</tr>
<tr>
<td>Survival at hospital discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUC (95% CI)</td>
<td>0.760 (0.746, 0.781)</td>
<td>0.740 (0.725, 0.754)</td>
</tr>
<tr>
<td>Intercept (95% CI)</td>
<td>0.024 (-0.183, 0.201)</td>
<td>-0.137 (-0.285, 0.012)</td>
</tr>
<tr>
<td>Slope (95% CI)</td>
<td>1.012 (0.933, 1.090)</td>
<td>0.878 (0.818, 0.939)</td>
</tr>
<tr>
<td>Hosmer-Lemeshow test</td>
<td>113.7 (0.001)</td>
<td>128.0 (0.001)</td>
</tr>
<tr>
<td>Brier’s score</td>
<td>0.071</td>
<td>0.072</td>
</tr>
</tbody>
</table>

Note: 1) AUC area under the curve or statistic. The closer the AUC gets to 1, the better the model is. 2) Cox Calibration regression: model is perfectly calibrated if intercept=0 and slope=1. 3) Hosmer-Lemeshow test assesses model’s goodness of fit. A small Chi-square with p>0.05 is considered good fit. 4) Brier score assesses the overall accuracy of prediction model. A low score (close to 0) indicates close agreement between observed and predicted values.

Figure 1: Observed vs predicted probability of ROSC at hospital transfer and survival to hospital discharge
Clinical paper

EuReCa ONE—27 Nations, ONE Europe, ONE Registry
A prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe


European Resuscitation Council

Abbreviations: ROSC = Return of spontaneous circulation, CPR = cardiopulmonary resuscitation, Abbreviations for Country names are explained in Table 1.

Fig. 5. Hospital survival rate in the Utstein Comparator Group (cardiac cause, shockable rhythms, and collapse bystander witnessed). Hospital survival data was available for 733 patients (seven countries with less than 10 cases were excluded: Austria, Cyprus, Ireland, Luxembourg, Portugal, Slovenia, Switzerland). The vertical lines represent the 95% confidence intervals. The percentage of patients per country who belong to the Utstein Comparator Group is marked with *. Abbreviations for Country names are explained in Table 1.

Discussion

This is the first study reporting incidence, community involvement (as bystander CPR), and outcomes following OHCA in 27 European countries. Assuming that the rate of OHCA was similar during the remaining eleven months of the year, we found an incidence rate of 84 per 100,000 population. A previous study reported 87.4 OHCA per 100,000 person-years for Europe. Thus, our results suggest that the incidence of OHCA in Europe is in the range of what has previously been reported.

We found the overall incidence of OHCA where CPR was started to be 49 patients per 100,000 population. This Fig. includes EMS and bystander treated cardiac arrests. It is clearly higher than previously reported from Europe ten years ago (38.0 per 100,000). On the other hand, our findings are in good agreement with more recent data from national surveys in Denmark and Sweden. In our study, for both these estimates, there was substantial variability between countries which may reflect a variation in disease, reporting bias or a natural variability which will be commented upon in the Limitations Section.
Collaborations

Prehospital Critical Care for Out-of-Hospital Cardiac Arrest

Johannes von Vopelius-Field, NIHR Doctoral Research Fellow

Does it improve survival?
Prospective observational study comparing survival after OHCA with prehospital critical care or ALS. Aim to include 5,000 cases.

How much does it cost?
Cost analysis of prehospital critical care using NHS ambulance trust and charity data.

How does it work?
Prospective observational analysis of prehospital critical care interventions.

'Right treatment for the right patient at the right time.'

How can we improve research in the field?
Qualitative focus groups with key stakeholders in prehospital care.
28,000 cardiac arrests
25.8% ROSC
7.9% survival to discharge
Quality of survival

12 months follow-up
12.2% alive (n=851)
Quality of survival

- Mobility: 66% No Problems, 33% Some Problems, 1% Extreme problem
- Selfcare: 88% No Problems, 11% Some Problems, 2% Extreme problem
- Activity: 68% No Problems, 27% Some Problems, 5% Extreme problem
- Pain: 72% No Problems, 25% Some Problems, 3% Extreme problem
- Anxiety: 66% No Problems, 29% Some Problems, 5% Extreme problem

Smith Circulation 2016
Return to work

796 survivors
75% returned to work at a median 4 of months
Average length of employment 11 years

Cumulative incidence (%)

Kragholm Circulation 2015
Early recognition and call for help
- to prevent cardiac arrest

Early CPR
- to buy time

Early Defibrillation
- to restart the heart

Post resuscitation care
- to restore quality of life
Importance of the First Link
Description and Recognition of an Out-of-Hospital Cardiac Arrest in an Emergency Call

Jocelyn Berdowski, MS, MSE; Freerk Beekhuis, RN; Aeilko H. Zwinderman, PhD; Jan G.P. Tijssen, PhD; Rudolph W. Koster, MD, PhD

P=0.038

3 month survival

Unrecognised

Dispatcher

Circulation 2009
Clinical paper

Briefer activation time is associated with better outcomes after out-of-hospital cardiac arrest


911 → Dispatch → Arrival

Activation interval

Response interval

n=2,687

Relative change in survival (%)
Dispatch-assisted CPR: Where are the hold-ups during calls to emergency dispatchers? A preliminary analysis of caller–dispatcher interactions during out-of-hospital cardiac arrest using a novel call transcription technique∗

Gareth R. Clegg a, b, Richard M. Lyon a, c, *, Scott James a, Holly P. Branigan d, Ellen G. Bard e, Gerry J. Egan f

Time to CA recognition 03:39 s (range 00:33–09:40)
Time to first chest compression 04:45 s (range 00:24–10:47)
Cardiac arrest recognition

- Unresponsive
- Not breathing normally
- Seizures

- Train bystanders and dispatchers to recognise agonal breathing

Perkins Circulation 2015
Ambulance telephone triage using ‘NHS Pathways’ to identify adult cardiac arrest

Charles D Deakin,¹,² Simon England,² Debbie Diffey²

Unconscious, fitting, choking

Normal breathing

CPR instructions
Ambulance telephone triage using ‘NHS Pathways’ to identify adult cardiac arrest

Charles D Deakin,¹,² Simon England,² Debbie Diffey²

- Sensitivity 0.759 (95% CI 0.74 to 0.77)
- Specificity 0.986 (95% CI 0.99 to 0.99)

<table>
<thead>
<tr>
<th>Category</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconscious</td>
<td>22.44</td>
</tr>
<tr>
<td>Breathing/respiratory</td>
<td>19.79</td>
</tr>
<tr>
<td>Chest pain</td>
<td>10.23</td>
</tr>
<tr>
<td>Concern for welfare</td>
<td>8.23</td>
</tr>
<tr>
<td>Other medical</td>
<td>4.52</td>
</tr>
<tr>
<td>Neurological</td>
<td>4.12</td>
</tr>
<tr>
<td>Trauma</td>
<td>3.85</td>
</tr>
<tr>
<td>Cold and clammy</td>
<td>2.52</td>
</tr>
<tr>
<td>Death/dying</td>
<td>1.46</td>
</tr>
</tbody>
</table>
YOU CAN'T IMPROVE WHAT YOU DON'T MEASURE.
Implementation of a Regional Telephone Cardiopulmonary Resuscitation Program and Outcomes After Out-of-Hospital Cardiac Arrest

Bently J. Bobrow, MD; Daniel W. Spaite, MD; Tyler F. Vadeboncoeur, MD; Chengcheng Hu, PhD; Terry Mullins, MBA; Wayne Tormala, MSW; Christian DamEFF, MD; John Gallagher, MD; Gary Smith, MD; Micah Panczyk, MS

- Before after study
- Dispatcher bundle
  - Dispatcher training
    - Simplified cardiac arrest recognition
    - Emphasis on time to T-CPR
- Quality improvement (system and individual)
Quality improvement metrics

(1) % recognised need for T-CPR
(2) % T-CPR instructions
(3) % bystander started CPR
(4) Time to recognition of CA
(5) Time from call to T-CPR instructions
(6) Time from call to first compression
Survival

Favourable neurological outcome

Before

After

Adj OR 1.47
95% CI 1.08-2.02

Adj OR 1.68
95% CI, 1.13-2.48

10% Increase T-CPR; Shorter time to T-CPR (42s)
• Increases chances resuscitation attempted by EMS OR 27.8 (95% CI 18.52-41.67)
  Rajagopal Resuscitation 2016

• Increases survival where CPR is attempted by EMS OR 2.44 (95% CI, 1.69 to 3.19)
  Sasson  Circ Cardiovasc Qual Outcomes 2010
Bystander CPR

* Norway, cardiac cause arrests

Norway (2008)
Seattle 2014
All school children are taught CPR and how to use an AED

Mrs Sheryll Murray (MP South East Cornwall) (Con): If somebody has a pulse that cannot be detected, or if somebody is breathing very shallowly, someone who comes along and starts to administer CPR could do damage to their health.
Everyone who is able to should learn CPR
2016: 150,000 children trained
Community intervention
- CPR in schools
- Mass CPR training

Dispatcher
First responders
Legislation – AED, CPR in schools
Post resuscitation care
- Survival to discharge 8.4% to 10.5%
- Favourable neurological outcome 9% to 9.5%
If an OHCA is suspected, the dispatcher activates the mobile-phone positioning system and standard EMS at the same time. The location of all laypersons who are trained in CPR is then determined and matched with the location of the incoming emergency call.

The geographic location of the source of all incoming emergency calls in Sweden can be determined automatically.
Mobile-Phone Dispatch of Laypersons for CPR in Out-of-Hospital Cardiac Arrest

Mattias Ringh, M.D., Mårten Rosenqvist, M.D., Ph.D., Jacob Hollenberg, M.D., Ph.D., Martin Jonsson, B.Sc., David Fredman, R.N., Per Nordberg, M.D., Hans Järnbort-Pettersson, Ph.D., Ingela Hasselqvist-Ax, R.N., Gabriel Riva, M.D., and Leif Svensson, M.D., Ph.D.

Adj Diff 14% (95% CI 6 to 21; P<0.001)
Early Defibrillation
- To restart the heart

Favourable neurological outcome %

Time to shock (min)

Blom Circulation 2014
The role of bystanders, first responders, and emergency medical service providers in timely defibrillation and related outcomes after out-of-hospital cardiac arrest: Results from a statewide registry

Carolina Malta Hansen, Kristian Kragholm, Christopher B. Granger,

![Graph showing the role of different responders in defibrillation and outcomes.](image-url)

Resuscitation 2015, 303-9
2% received PAD

P < 0.001 for trend in the total cohort and each age group

Any age

18–74 yr of age

≥ 75 yr of age

0–17 yr of age

NEJM 2015
Reduced time to first shock by 2 min 39 s compared to EMS

Zijlstra et al. Resuscitation 2014
GoodSAM
The World’s Most Advanced Emergency Alerting platform

GoodSAM Pro
www.goodsamapp.org
AED locator

Contact: gillian.hodgetts@scas.nhs.uk
Early recognition and call for help - to prevent cardiac arrest

Early CPR - to buy time

Early Defibrillation - to restart the heart

Post resuscitation care - to restore quality of life
Volume versus outcome: More emergency medical services personnel on-scene and increased survival after out-of-hospital cardiac arrest

Sam A. Warren\textsuperscript{a,b,}\ast, David K. Prince\textsuperscript{d,g}, Ella Huszti\textsuperscript{a,b}, Tom D. Rea\textsuperscript{b}, Annette L. Fitzpatrick\textsuperscript{c,e,f}, Douglas L. Andrusiek\textsuperscript{h}, Steve Darling\textsuperscript{i}, Laurie J. Morrison\textsuperscript{j}, Gary M. Vilke\textsuperscript{k}, Graham Nichol\textsuperscript{a,b,g}, the ROC Investigators

Odds ratio = 1.35 (95\% CI: 1.05, 1.73)
Skilled teams

Paramedic exposure to cardiac arrest influences survival

Dyson Circ Cardiovasc Qual Outcomes. 2016

Cardiac arrests attended in previous 3 years

- >17: 1.50 (1.22-1.86)
- >11-17: 1.29 (1.04-1.59)
- >6-11: 1.26 (1.04-1.54)
- ≤6: Reference

Time since attended last cardiac arrest (months)

- >6: 0.70 (0.54-0.91)
- >3-6: 0.95 (0.80-1.14)
- >1-3: 1.08 (0.95-1.24)
- ≤1: Reference
High quality CPR

![Graph showing the relationship between depth and probability of survival.](image1)

![Graph showing the relationship between average chest compression rate and probability of survival to discharge.](image2)

n=6399
Avoid interruptions in compressions

Lower odds ratio (OR) for survival per 5 second increase in:

- Longest overall pause  OR 0.85 (0.77–0.93)
- Longest peri-shock  OR 0.85 (0.77–0.93)
- Longest non-shock  OR 0.83 (0.75–0.91)

Message:
Any pause is bad

319 OHCAs VF/VT

Brouwer TF Circulation 2015
Drilled teams

Focus on monitor

Defib, IV/IO Meds

Airway, Drug prep

Others need to help #1:
1. Make sure Chest Compressor can see monitor!!!
2. Do not interrupt Chest Compressors—they need to focus on delivery of quality chest compressions.

Chest Compressors (switch every 2 min)!!

Second compressor, IV Prep and watch monitor
Improved survival

Adj OR 2.7 (1.1-6.4)
Adj OR 2.69 (1.04-6.94)
Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

% survival to discharge

Amiodarone, Lidocaine, or Placebo

NEJM 2016
Airway management in cardiac arrest patients

The Adrenaline Trial
Why do outcomes of hospitalised patients with first out of hospital cardiac arrest from Acute Coronary Syndrome (ACS) vary in England and Wales?
Caterpillar plot for odds ratio of in-hospital mortality (adjusted analysis)

<table>
<thead>
<tr>
<th>Variable (Baseline category)</th>
<th>Category</th>
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<td>Age (NA)</td>
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<td>Smoking status (Never smoked)</td>
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<td>OHCA after ambulance (No)</td>
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<td>ECG determining treatment (Other acute abnormality or no acute changes)</td>
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<td>Hospital volume (25 – 82 cases)</td>
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<tr>
<td>Hospital PCI capability (PCI incapable)</td>
<td>NA</td>
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<tr>
<td>Reperfusion treatment with time (None)</td>
<td>NA</td>
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<tr>
<td>Admission w ard (Cardiac care unit)</td>
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<tr>
<td>Admitting consultant (Other consultant)</td>
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EMS witnessed Shockable rhythms PCI capable centre Time to PCI (Predominantly STEMI)
Network for Emergency Care Clinical Trials: Strategies to Innovate EmeRgENcy Care Clinical Trials Network (SIREN) - Network Clinical Center (Hub) (U24)
Early recognition and call for help
- to prevent cardiac arrest
- to buy time

Early CPR
- to restart the heart

Early Defibrillation
- to restore quality of life

Post resuscitation care
UK-ROC

- Epidemiology and outcome
- Clinical Quality Improvement
- Observational studies
- Randomised controlled trials

developing knowledge and capacity to save lives
developing knowledge and capacity to save lives
Summary

- 28k cardiac arrests less than 1 in 10 survive
- System wide approaches early in Chain of Survival likely to have greatest impact
  - Dispatcher, CPR, Defibrillation
- Drive for excellence
- Research, audit, quality improvement