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Clinical Paper

Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit☆

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ABSTRACT

Objective: To report the incidence, characteristics and outcome of adult in-hospital cardiac arrest in the United Kingdom (UK) National Cardiac Arrest Audit database.
Methods: A prospectively defined analysis of the UK National Cardiac Arrest Audit (NCAA) database. 144 acute hospitals contributed data relating to 22,628 patients aged 16 years or over receiving chest compressions and/or defibrillation and attended by a hospital-based resuscitation team in response to a 2222 call. The main outcome measures were incidence of adult in-hospital cardiac arrest and survival to hospital discharge.
Results: The overall incidence of adult in-hospital cardiac arrest was 1.6 per 1000 hospital admissions with a median across hospitals of 1.5 (interquartile range 1.2–2.2). Incidence varied seasonally, peaking in winter. Overall unadjusted survival to hospital discharge was 18.4%. The presenting rhythm was shockable (ventricular fibrillation or pulseless ventricular tachycardia) in 16.9% and non-shockable (asystole or pulseless electrical activity) in 72.3%; rates of survival to hospital discharge associated with these rhythms were 49.0% and 10.5%, respectively, but varied substantially across hospitals.
Conclusions: These first results from the NCAA database describing the current incidence and outcome of adult in-hospital cardiac arrest in UK hospitals will serve as a benchmark from which to assess the future impact of changes in service delivery, organisation and treatment for in-hospital cardiac arrest.

1. Introduction

The treatment of in-hospital cardiac arrest accounts for a significant workload in most acute hospitals in the United Kingdom (UK) and internationally. Despite this, there are no reliable national data to enable accurate determination of the incidence and outcome of in-hospital cardiac arrest in the UK. Data from a single UK general hospital in 1999 documented an incidence of in-hospital cardiac arrest of 3.6 per 1000 admissions (equivalent to 0.3 per 1000 population).[1] A one-off audit undertaken in 1997 of in-hospital cardiac arrest in 49 UK hospitals reported a survival rate to hospital discharge of 17.6% but the number of hospital admissions over the audit period was not documented.[2]

A review of in-hospital cardiac arrest studies internationally documented incidences in the range of 1–5 per 1000 hospital admissions but with widely variable survival rates (0–42%).[3] A recent analysis of the American Heart Association (AHA) Get with the Guidelines (GWTG)-Resuscitation registry, that included 358 hospitals with at least 50 adult in-hospital cardiac arrest cases between 2000 and 2009, documented a median incidence of 4.02 in-hospital cardiac arrests per 1000 hospital admissions (interquartile range (IQR), 2.95–5.65 per 1000 admissions).[4] The median survival rate to hospital discharge for this period was 18.8% (IQR 14.5–22.6%).

In the UK, clinical guidelines for the prevention and treatment of cardiac arrest are updated at least every five years. However, the impact of guideline changes and other interventions on the

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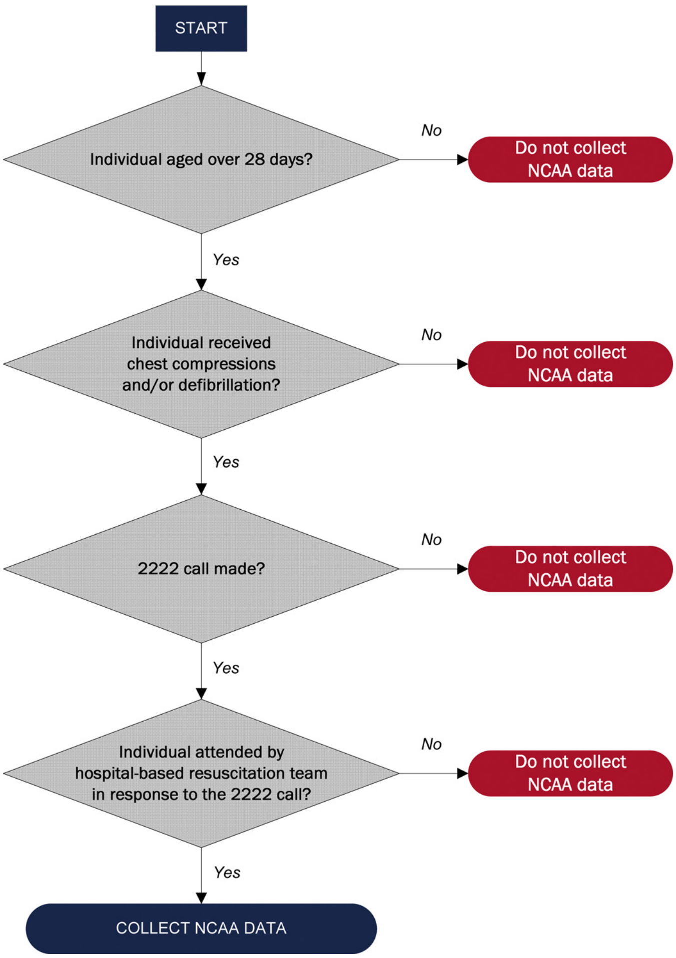

Fig. 1. Scope of data collection for the National Cardiac Arrest Audit.

incidence and outcome of in-hospital cardiac arrest can be determined only if these data can be collected consistently and reliably. Data from the AHA GWTG-Resuscitation registry indicate that risk-adjusted rates of survival to discharge after in-hospital cardiac arrest have increased from 13.7% in 2000 to 22.3% in 2009 (adjusted rate ratio per year, 1.04; 95% confidence interval (CI) 1.03–1.06; $P < 0.001$ for trend).[5]

The Resuscitation Council (UK) and the Intensive Care National Audit & Research Centre (ICNARC) have collaborated to establish the UK national clinical audit for in-hospital cardiac arrest: the National Cardiac Arrest Audit (NCAA).[6] The aim of NCAA is to promote improvements in resuscitation care and outcomes through the provision of timely, validated comparative data to participating hospitals. The aim of this analysis is to report the incidence, characteristics and outcome of adult in-hospital cardiac arrest in the UK National Cardiac Arrest Audit database.

2. Methods

2.1. The National Cardiac Arrest Audit

NCAA is a subscription-based, national clinical audit of patients greater than 28 days of age in acute hospitals in the UK who receive cardiopulmonary resuscitation (CPR) following an in-hospital cardiac arrest and are attended by the hospital-based resuscitation team (or equivalent) in response to a 2222 call (2222 is the emergency telephone number used to summon a resuscitation team in UK hospitals; Fig. 1). CPR is defined by NCAA as the receipt of chest compressions and/or defibrillation. NCAA received approval from the National Information Governance Board (now the Confidentiality Advisory Group within the Health Research Authority) to hold patient identifiable data under section 251 of the NHS Act 2006. Approval Number: ECC 2-06(n)/2009.

Table 1
National Cardiac Arrest Audit (NCAA) dataset.

Denominator data (monthly):
Total number of admissions to the hospital
Total number of 2222 calls or total number of 2222 calls solely for cardiac arrest
Patient/cardiac arrest data:
Record number (automated)
National Health Service number
Date of birth or estimated age (if date of birth not available)
Sex
Ethnicity
Date of admission to/attendance at/visit to the hospital
Reason for admission to/attendance at/visit to the hospital
Date/time of 2222 call
Status at resuscitation team arrival
Location of arrest
Presenting/first documented rhythm
Reason resuscitation stopped at end of team visit
Transient post-arrest location
Post-arrest location
Status at discharge from the hospital
Sedated at discharge from the hospital
Date of discharge from the hospital
Cerebral Performance Category at discharge from the hospital
Date/time of death
Additional information (free text)

2.2. Data collection

Standardised data are collected at the time of the cardiac arrest and from the medical records according to strict rules and definitions (Table 1) and online appendix. The precise definitions are listed in an online appendix. Staff at participating hospitals enter NCAA data onto a dedicated secure online system. Data are validated both at the time of entry and centrally, being checked for completeness, illogicalities and inconsistencies.

2.3. Inclusion and exclusion criteria

Data collection for NCAA started in November 2009 but the initial scope included only those cardiac arrest patients actually resuscitated by the resuscitation team. From April 2011 the scope changed to include any cardiac arrest that resulted in attendance by the team. Thus, we undertook a prospectively defined analysis of the NCAA database for the period 1st April 2011 to 31st March 2013. All in-hospital cardiac arrests of patients aged 16 years or over were included in the analysis. Pre-hospital cardiac arrests, included in the NCAA database because the resuscitation team is called to the emergency department to continue the resuscitation attempt, were excluded.

2.4. Statistical analysis

The incidence of in-hospital cardiac arrests per 1000 hospital admissions was calculated overall, by hospital and over time. The case mix of patients was described, including age, sex, ethnicity and reason for admission. The frequency of in-hospital cardiac arrests was calculated for day versus night (defined as 8:00–19:59 and 20:00–7:59, respectively) and weekday versus weekend (defined as Monday 08:00 to Saturday 07:59 and Saturday 08:00 to Monday 07:59, respectively). Median time from hospital admission to cardiac arrest was calculated and the presenting rhythm and

Table 2
The Cerebral Performance Category (CPC) scale.

CPC	Label	Description
1	Good cerebral performance (*normal life*)	Conscious, alert, able to work and lead a normal life. May have minor psychological or neurologic deficits (mild dysphasia, nonincapacitating hemiparesis, or minor cranial nerve abnormalities).
2	Moderate cerebral disability (*disabled but independent*)	Conscious. Sufficient cerebral function for part-time work in sheltered environment or independent activities of daily life (dress, travel by public transportation, food preparation). May have hemiplegia, seizures, ataxia, dysarthria, dysphasia, or permanent memory or mental changes.
3	Severe cerebral disability (*conscious but disabled and dependent*)	Conscious; dependent on others for daily support (in an institution or at home with exceptional family effort). Has at least limited cognition. This category includes a wide range of cerebral abnormalities, from patients who are ambulatory but have severe memory disturbances or dementia precluding independent existence to those who are paralysed and can communicate only with their eyes, as in the locked-in syndrome.
4	Coma/vegetative state (*unconscious*)	Unconscious, unaware of surroundings, no cognition. No verbal or psychological interaction with environment.
5	Brain death (*certified brain dead or dead by traditional criteria*)	Certified brain dead or dead by traditional criteria.

location of arrest were summarised. The rates of return of spontaneous circulation (ROSC), survival to hospital discharge and good neurological outcome were also calculated. A patient was considered to achieve ROSC only if ROSC was sustained for greater than 20 min. Neurological outcome was recorded using the Cerebral Performance Category (CPC) scale (Table 2) and, in accordance with convention, a CPC of 1 or 2 was defined as a 'good' outcome. Survival to hospital discharge was calculated overall, by cardiac arrest rhythm, by age, for day versus night and for weekday versus weekend. All statistics were calculated using Stata Version 10.1.

3. Results

A total of 144 acute hospitals contributed data from the period 1st April 2011 to 31st March 2013. Due to hospitals joining NCAA at different times, individual hospital participation ranged from 2 to 24 months. Overall, 23,554 in-hospital cardiac arrests were reported for 22,628 patients (range 0–665 cardiac arrests for individual hospitals). The total number of hospital admissions for this period was 14,784,144, giving an overall incidence of adult in-hospital cardiac arrest, attended by a hospital-based resuscitation team, of 1.6 per 1000 hospital admissions. For individual hospitals, the median incidence was 1.5 per 1000 hospital admissions (IQR 1.2–2.2). Incidence varied seasonally, peaking in winter (December, January and February; Fig. 2).

The main characteristics of adult patients having an in-hospital cardiac arrest are shown in Table 3. The mean age was 74 years, 57% of patients were male and the vast majority were of white ethnicity. Over 80% were classified as medical patients. There was no difference in the relative frequency of arrests, per hospital per 12 h, between night (20:00–07:59; 0.14) and day (08:00–19:59; 0.14) or, per hospital per day, between weekend (0.27) and weekday (0.28). Analysis of the time of the cardiac arrest calls shows a peak at 06:00

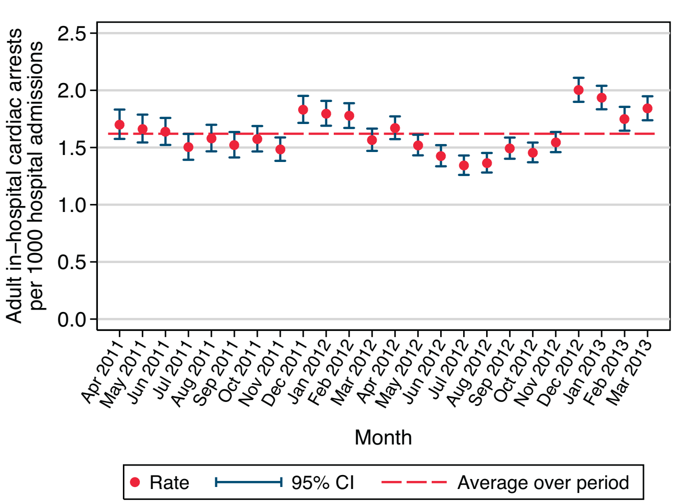

Fig. 2. Incidence of adult in-hospital cardiac arrests (per 1000 hospital admissions) over time.

Table 3
Characteristics of 22,628 adult patients having an in-hospital cardiac arrest.

Characteristic	Number (%) (unless indicated)[a]
Age, mean (SD)	73.9 (14.2) [22,598]
Sex, male	12,946 (57.2) [22,616]
Ethnicity	[22,628]
White	19,486 (86.1)
Mixed	112 (0.5)
Asian	659 (2.9)
Black	282 (1.2)
Other	223 (1.0)
Not stated	1866 (8.2)
Reason for admission to/attendance at hospital	[22,608]
Patient – trauma	861 (3.8)
Patient – medical	18,296 (80.9)
Patient – elective/scheduled surgery	1439 (6.4)
Patient – emergency/urgent surgery	1708 (7.6)
Patient – obstetric	44 (0.2)
Outpatient	211 (0.9)
Staff	11 (<0.1)
Visitor	38 (0.2)

[a] Numbers in square brackets indicate the actual number of patients with data recorded.

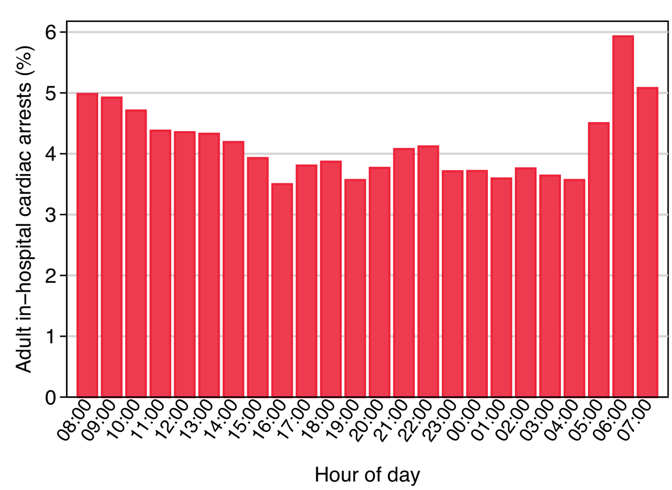

Fig. 3. Hour of the day of adult in-hospital cardiac arrests.

Table 4
Location of arrest for 23,554 adult in-hospital cardiac arrests.

Location of cardiac arrest	Number (%)[a]
Emergency department	2308 (9.8)
Emergency admissions unit	1988 (8.4)
Theatre and recovery	282 (1.2)
Imaging department	309 (1.3)
Cardiac catheter laboratory	698 (3.0)
Specialist treatment area	275 (1.2)
ICU or ICU/HDU	1215 (5.2)
HDU	404 (1.7)
CCU	2438 (10.4)
Other intermediate care area	59 (0.3)
Obstetrics area	34 (0.1)
Ward	13,338 (56.6)
Other internal location	8 (<0.1)
Clinic	76 (0.3)
Non-clinical area	118 (0.5)

[a] Location of arrest not reported for 4 arrests, ICU: intensive care unit, HDU: high dependency unit, CCU: coronary care unit.

(Fig. 3). Cardiac arrests occurred a median of 2 days after admission (IQR 0–7). Over half (13,338, 56.6%) of cardiac arrests occurred on general wards (Table 4). Presenting rhythm was shockable (ventricular fibrillation or pulseless ventricular tachycardia (VF/VT)) in 16.9% and non-shockable (asystole or pulseless electrical activity, PEA) in 72.3% of arrests (Table 5).

Overall rates of ROSC of greater than 20 min and survival to hospital discharge (hospital survival) were 45.0% and 18.4% respectively (Table 5). Hospital survival was higher following VF/VT cardiac arrest (49.0%) than for asystole or PEA (11.4% and 8.7%, respectively – 10.5% combined; Table 5). Hospital survival rates varied substantially by presenting rhythm and by hospital (Fig. 4). Cerebral Performance Category data was collected on 3857 (92.7%) of the 4153 patients who survived to discharge. Of these patients, the neurological outcome of 3,759 (97.5%) was documented as CPC 1 or 2. Crude hospital survival suggested worse outcomes for arrests at night (13.8%) than day (23.0%) and for arrests at weekends (16.1%) than weekdays (19.3%). The outcome by age (in ten year groups) is shown in Fig. 5.

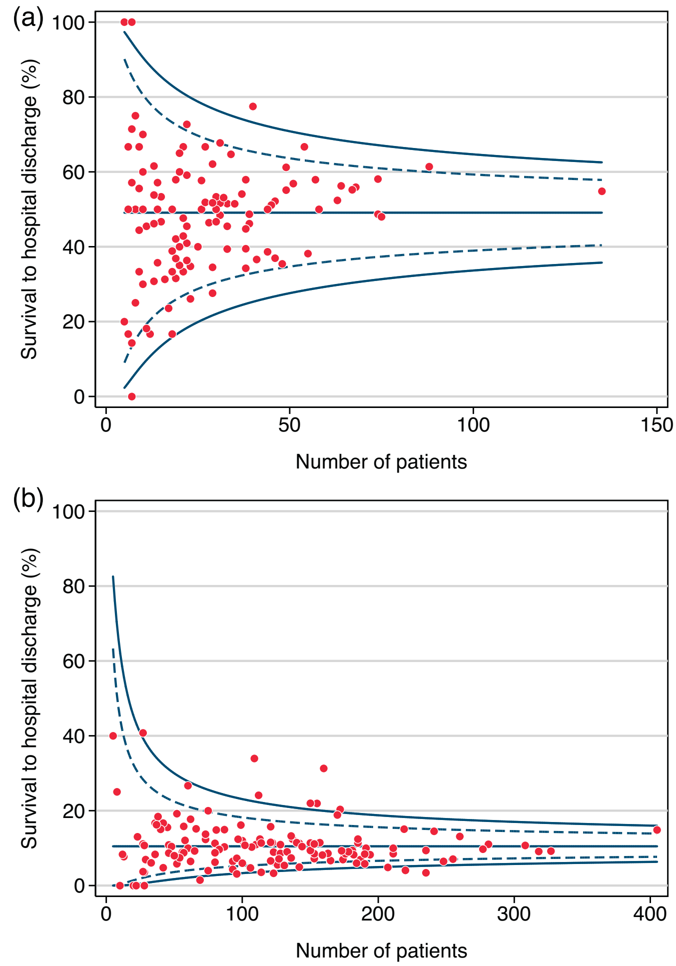

Fig. 4. Funnel plots of survival to hospital discharge following adult in-hospital cardiac arrest for (a) shockable and (b) non-shockable rhythms.

4. Discussion

In 144 UK acute hospitals for the period 1st April 2011 to 31st March 2013, the overall incidence of adult in-hospital cardiac arrest, attended by a hospital-based resuscitation team, was 1.6 per 1000 hospital admissions with a median across hospitals of 1.5 (IQR 1.2–2.2). Overall unadjusted survival to hospital discharge was 18.4%. Presenting rhythm was shockable (VF/VT) for 16.9% and non-shockable (asystole/PEA) for 72.3%; rates of survival to hospital discharge associated with these rhythms were 49.0% and 10.5%, respectively, but varied substantially across hospitals.

The median incidence of adult in-hospital cardiac arrest for individual hospitals in our study was much lower than the 4.02 per 1000 hospital admissions (IQR 2.95–5.65) documented in the AHA GWTG-Resuscitation registry.[4] However, there is a fundamental difference in the scope of the two datasets. NCAA is not a cardiac arrest registry; it is a national clinical audit set up to monitor the impact of the resuscitation team on patient outcome (rather than a register of all known events). To this end, it includes only those in-hospital cardiac arrests that led to attendance by the resuscitation team (in response to a 2222 call). Many cardiac arrests in monitored areas, for example in intensive care units (ICUs), are managed without either a 2222 call or the attendance of the hospital-based resuscitation team and reliable capture of data relating to these events may be considered by NCAA in the future. In our study, 56.6% of cardiac arrests occurred in general wards where most patients are likely to have been unmonitored. This is in marked contrast to the AHA GWTG-Resuscitation registry, which, in the most recently reported period (2007–2009), documented that 84.6% of cardiac arrests occurred in monitored areas.[5] This difference is further

Table 5
First documented rhythm and outcome for 23,554 adult in-hospital cardiac arrests.

First documented rhythm	All rhythms[a]	VF/VT	PEA	Asystole
Number (%)	23,554(100)	3982 (16.9)	11,455 (48.6)	5563 (23.6)
ROSC > 20 minutes, *n* (%)	10,607 (45.0)	3029 (76.1)	4688 (40.9)	1460 (26.2)
Survival to hospital discharge[b], *n* (%)	4153 (18.4)	1727 (49.0)	1265 (11.4)	470 (8.7)
CPC 1 or 2[c], *n* (%)	3759 (97.5)	1602 (99.1)	1114 (95.6)	410 (96.7)

[a] All rhythms includes VF/VT, PEA, Asystole as well as 101 non-shockable bradycardia, 491 non-shockable unknown rhythm, 139 shockable unknown rhythm, 288 never determined and 1535 unknown.
[b] Excluding 926 revisits by the resuscitation team for repeat cardiac arrests and 98 with missing outcome.
[c] Shown as a percentage of 3857 survivors at hospital discharge where CPC could be assessed.

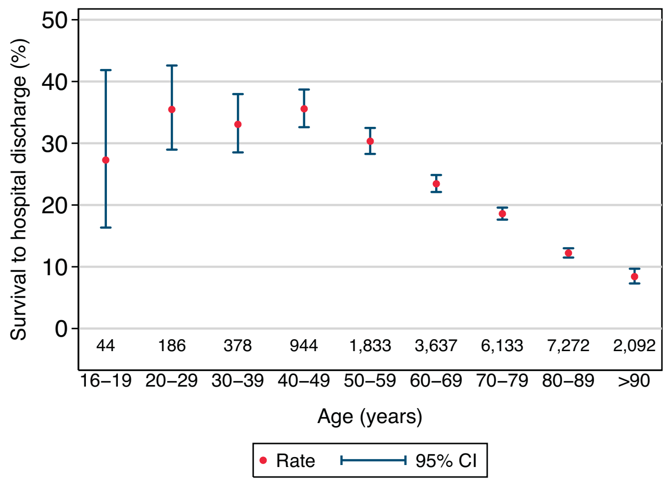

Fig. 5. Survival to hospital discharge following in-hospital cardiac arrest by age. The number of patients in each decile is indicated above the *x* axis.

compounded by the marked difference between the two countries in the proportion of acute care hospital beds that are ICU beds: 9.0% in the US versus 1.2% in the UK.[7] Despite these differences in scope, unadjusted hospital survival in the UK appears remarkably similar to that reported for adult in-hospital cardiac arrests from the AHA GWTG-Resuscitation registry in 2009 (18.6%).[5]

The proportion of cases with a shockable first documented rhythm of VF/VT was similar in NCAA compared with the GWTG-Resuscitation registry (16.9% and 18.5%, respectively).[5] However, unadjusted survival to hospital discharge from a shockable rhythm was higher in the UK (49.0% versus 37.2%). Our findings that unadjusted survival to hospital discharge is worse following cardiac arrest at night compared with during the day, and at weekends compared with weekdays, are consistent with data from the AHA GWTG-Resuscitation registry[8]; however, these data require risk-adjustment before any inference can be made about the potential differences.[9] The wide variation in outcomes from in-hospital cardiac arrest across hospitals also requires risk adjustment; in the US, variation across hospitals was substantially narrower following adjustment.[9,10] They have also shown an association between the lowest incidence of cardiac arrest and the highest risk-adjusted survival rates.[4] To explore this, and other hypotheses, in the UK a multivariable risk model using NCAA data has been developed and is described in an accompanying paper.[11] The 06.00 peak in the incidence of cardiac arrest is striking and is in marked contrast with an analysis of the GWTG-R registry, which showed no such peak; if anything, the incidence of cardiac arrest at 06:00 is at its lowest.[8] This difference between the two studies may reflect the relatively low proportion of monitored patients in the NCAA dataset compared with those in GWTG-R registry as discussed previously. Thus the morning peak identified in our study probably includes individuals found to be in cardiac arrest when nursing staff attempted to wake them up. Data about whether an arrest is witnessed or not is not included in the NCAA dataset. A peak in cardiac arrests at 06:00 could also be caused by changes in hormone concentrations, blood pressure or intracardiac ion channel opening, all of which appear to change diurnally.[12,13]

Decreasing survival to hospital discharge at older ages is also compatible with results from the AHA GWTG-Resuscitation registry, where investigators have reported that age ≥80 years is associated with an odds ratio for hospital survival of 0.57 (95% CI 0.52–0.63) compared with the reference age range of 60–69 years.[14] In our analysis, 40.9% of patients were aged 80 years or more at the time of CPR. Survival to hospital discharge for this group was 11.4%.

The strengths of our study are: the large number of hospitals included, representing approximately 60% of acute hospitals in the UK; the standardised data collection according to strict rules and definitions; and the comprehensive data validation, both at the time of entry and when pooled centrally prior to analysis.

4.1. Study limitations

A weakness of our study is that although all hospitals log their 2222 calls, this same number is often used for all emergencies (e.g. fire) and we cannot be absolutely certain that we have captured all cardiac arrests that fulfil the NCAA inclusion criteria. Another weakness relates to the completeness and accuracy of neurological outcome data. Of the 4153 survivors to hospital discharge, we have CPC scores for 3.857 (92.9%). We do not know the reason for the missing scores other than failure to follow up patients by the admitting hospitals. We do not know whether these data are collected accurately and consistently and are undertaking a study to evaluate this. The proportion of patients classified as CPC 1 in NCAA is considerably higher than other studies – for example, in 2007–2009, the AHA GWTG-Resuscitation registry reported that 51.3% of hospital survivors were assessed as CPC 1 and 19.5% were CPC 3 or worse.[5] However, data from this registry also shows that in the same period 54.2% of patients were CPC 1 and 18.5% were CPC 3 or worse *before* their cardiac arrest. Differences in the proportion of patients with CPC scores of 3 or more (both before and after cardiac arrest) may therefore result from differences between UK and US hospitals in the application of do-not-attempt cardiopulmonary resuscitation (DNACPR) decisions.

5. Conclusion

These first results from the NCAA database describing the current incidence and outcome of adult in-hospital cardiac arrest in UK hospitals will serve as a benchmark from which to assess the future impact of changes in service delivery, organisation and treatment for in-hospital cardiac arrest. The development and validation of a risk model will enable more meaningful comparisons across hospitals, between patient groups, and over time.[11] Inclusion of the patient's National Health Service (NHS) number (a unique number for each individual in the UK) in the NCAA database also enables linkage with other patient databases, for example, other national clinical audits, to allow us to better understand the full patient journey and longer-term outcomes. In time, additions to the NCAA dataset will enable evaluation of other potential risk factors (e.g. comorbidities), interventions (e.g. specific drug therapies and post cardiac arrest treatments) and outcomes (e.g. longer-term neurological outcome) both to generate hypotheses and for NCAA to form the platform for large-scale multicentre randomised controlled trials on in-hospital cardiac arrest in the UK.

Conflict of interest statement

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that JPN, JS, GBS, CG, FP, SP, DH, EN and KR have no non-financial interests that may be relevant to the submitted work. JPN is Editor-in-Chief of Resuscitation. JS is an Editor for Resuscitation.

Authors contribution

All authors have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted. JPN is responsible for the overall content as guarantor.

Appendix A. Members of the National Cardiac Arrest Audit Steering Group

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Ian Maconochie (from 2013)
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Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2014.04.002.

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