



Incidence, location and reasons for avoidable in-hospital cardiac arrest in a district general hospital

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Abstract

Aims: To determine the incidence of avoidable cardiac arrest among patients who had received resuscitation in a district general hospital. To establish how location and individual or system factors influence avoidable cardiac arrest in order to develop an evidence-based preventive strategy. **Methods:** Expert panel review of case-notes from 139 consecutive adult in-hospital cardiac arrests over 1 year. **Results:** There were 32 348 adult admissions in 1999 with 1023 deaths. The cardiac arrest team was activated 139 times: 118 were for primary in-hospital cardiac arrest. The cardiac arrest rate excluding 'do not attempt resuscitation' (DNAR) cases was 3.8/1000 admissions. In 88.5% of deaths there was a DNAR policy. Survival to hospital discharge following resuscitation was 14%. Among the 118 cases, the panel unanimously agreed that 61.9% of arrests were potentially avoidable, rising to 68% when emergency department arrests were excluded (66 and 73% for majority opinion). Cardiac arrests were more likely at the weekend than during the week ($P = 0.02$). The odds of potentially avoidable cardiac arrest was 5.1 times greater for patients in general wards than critical care areas ($P < 0.001$); patients in critical care areas were more likely to survive ($P < 0.001$). The odds of potentially avoidable cardiac arrest was 12.6 times greater for patients nursed in a clinical area judged 'inappropriate' for their main complaint ($P < 0.002$, Fisher's exact test) compared to those nursed in 'appropriate' areas. The panel agreed that 100% of potentially avoidable arrests were judged to have received inadequate prior treatment. Clinical signs of deterioration in the preceding 24 h were not acted upon in 48%, and review was confined to a house officer in 45%. **Conclusion:** The majority of treated in-hospital cardiac arrests are potentially avoidable. Multiple system failures include delays and errors in diagnosis, inadequate interpretation of investigations, incomplete treatment, inexperienced doctors and management in inappropriate clinical areas. © 2002 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: In-hospital cardiac arrest; Incidence; Location; Avoidable

Resumo

Objectivo: Determinar a incidência de paragens cardíacas evitáveis entre as vítimas de PCR que foram alvo de manobras de reanimação cardio-respiratória (RCR) num hospital distrital. Estabelecer a eventual relação entre o local da PCR e factores individuais e do sistema que possam relacionar-se com as PCR evitáveis, desenvolvendo desta forma uma estratégia preventiva com base na evidência. **Métodos:** Um painel de peritos reviu as notas de 139 PCR intra-hospitalares consecutivas em adultos durante um ano. **Resultados:** Houve 32348 admissões de adultos em 1999 com 1023 mortes. A equipa de paragem cardíaca foi activada 139 vezes: 118 por PCR intra-hospitalar primária. A taxa de paragem cardíaca excluindo os casos 'do not attempt resuscitation' (DNAR) foi de 3.8/1000 admissões. Em 88.5% das mortes existia uma política de DNAR. A sobrevivência à alta hospitalar após reanimação foi de 14%. Entre os 118 casos, os peritos do painel concordaram unanimemente que 61.9% das paragens eram potencialmente evitáveis, aumentando para 68% quando foram excluídas as paragens cardíacas no departamento de Emergência (66 e 73% por opinião da maioria). As paragens cardíacas eram mais prováveis ao fim de semana do que durante a semana ($P = 0.02$). A

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taxa de paragem cardíaca potencialmente evitável foi 5.1 vezes superior para os pacientes em enfermarias gerais do que para os pacientes em áreas de cuidados críticos ($P < 0.001$); os pacientes em áreas de cuidados críticos tinham maior probabilidade de sobreviver ($P < 0.001$). A taxa de paragens cardíacas potencialmente evitáveis foi 12.6 vezes superior para vítimas a quem eram prestados cuidados em áreas clínicas julgadas como ‘inapropriadas’ para a sua queixa principal ($P < 0.002$, teste exacto de Fisher) comparativamente com aqueles a quem foram prestados cuidados em áreas consideradas ‘apropriadas’. O painel de peritos concordou que em 100% das paragens potencialmente evitáveis o tratamento prévio foi inadequado. Sinais clínicos de deterioração nas 24 horas precedentes não foram detectados em 48% dos casos, e a revisão esteve confinada a um interno geral em 45%. *Conclusão:* A maioria das paragens cardíacas intra-hospitalares tratadas eram potencialmente evitáveis. Falências de múltiplos sistemas incluíam atrasos e erros no diagnóstico, interpretação inadequada das investigações realizadas, tratamento incompleto, médicos inexperientes e abordagem em áreas clínicas inapropriadas. © 2002 Elsevier Science Ireland Ltd. All rights reserved.

Palavras chave: Paragem cardíaca intra-hospitalar; Incidência; Evitável

Resumen

Objetivos: Determinar la incidencia de paro cardíaco prevenible entre los pacientes que han recibido reanimación cardiopulmonar en un hospital general distrital. Establecer de que manera influyen en el paro cardíaco evitable, la localización y factores individuales o del sistema, para desarrollar una estrategia de prevención basada en evidencia. *Métodos:* Revisión, por un panel de expertos, de las notas de 139 paros cardíacos de adultos intrahospitalarios consecutivos ocurridos en un año. *Resultados:* hubo 32348 admisiones de adultos en 1999 con 1023 muertes. El equipo de paro cardíaco fue activado 139 veces: 118 de ellas por paro cardíaco primario intrahospitalario. La tasa de paro cardíaco, excluyendo los casos con ‘orden de no intentar reanimación’(DNAR) fue 3.8/1000 admisiones. En el 88.5% de las muertes había política de DNAR. La sobrevida al alta hospitalaria después de reanimación fue 14%. Entre los 118 casos, el panel acordó unánimemente que 61,9% de los paros eran potencialmente prevenibles, elevándose a 68% cuando se excluyen los paros de la unidad de emergencia (66 y 73% por opinión mayoritaria). Los paros eran mas probables durante los fines de semana que durante la semana ($P = 0.02$). La probabilidad de paro cardíaco potencialmente evitable fue 5.1 veces mayor para pacientes en salas comunes que en áreas de cuidados críticos ($P < 0.001$); los pacientes en áreas de cuidados críticos tenían mas probabilidades de sobrevivir ($P < 0.001$). La probabilidad de paro cardíaco potencialmente evitable fue 12.6 veces mayor para pacientes cuidados en áreas clínicas juzgadas ‘inapropiadas’ para su problema principal ($P < 0.002$, test exacto de Fisher) comparando aquellos cuidados en áreas juzgadas como ‘apropiadas’. El panel acordó que en el 100% de los paros cardíacos potencialmente evitables fueron juzgados como habiendo recibido tratamiento previo inadecuado. Los signos clínicos de deterioro en la 24 horas previas no recibieron acciones consecuentes en 48%, y la revisión fue confinada a un auxiliar en 45%. *Conclusiones:* La mayoría de los paros cardíacos intrahospitalarios tratados son potencialmente evitables. Las fallas en múltiples sistemas incluyen demora y errores en el diagnóstico, interpretación inadecuada de investigaciones, tratamiento incompleto, doctores inexpertos y manejo en áreas clínicas inadecuadas. © 2002 Elsevier Science Ireland Ltd. All rights reserved.

Palabras clave: Paro Cardíaco intrahospitalario; Incidencia; Evitable

1. Introduction

There are an estimated 850 000 adverse events per year in NHS hospitals resulting in harm to patients [1]. Risk factors for in-hospital cardiac arrest [2–5] and for unplanned intensive care unit admission from a general ward [6–9] have been widely described. Observable evidence of deterioration in up to 84% of cases in the 8 h prior to arrest has led authors to conclude that cardiac arrest may often be avoidable [2–4]. No study to date has addressed the overall incidence of avoidable in-hospital cardiac arrest and resultant avoidable death.

A small study of hospital deaths following emergency admissions resulting in medico-legal claims showed 69% (20/29) were potentially avoidable [10], but the population was highly selected. Effective risk management necessitates that avoidable in-hospital cardiac arrest is minimised. A reduction in avoidable cardiac arrest requires trends in failure of individual doctors and nurses to be identified [3,11], together with the organisa-

tional factors that provide the conditions in which errors occur [12].

As a preventive strategy, hospitals in Australia and the United Kingdom have used clinical teams with empirical-based activation criteria [1,13–16]. Our study aimed to determine the incidence of avoidable cardiac arrest among patients who had received resuscitation, and to establish how the location and individual or system factors influenced avoidability in order to develop an evidence-based preventive strategy.

2. Methods

2.1. Setting

An acute district general hospital in south-east England with 700 beds (6 intensive care, 5 high dependency, 4 coronary care) and a catchment population of around 365 000. The cardiac arrest team (CAT)

is led by a medical registrar or senior house officer and includes an anaesthetist, resuscitation officer, house officer/s and ward-based nursing staff. The CAT is alerted to an arrest and its location via a pager, triggered by a central switchboard immediately following notification of cardiac arrest.

2.2. Definitions

In-hospital cardiac arrest was defined as a loss of spontaneous circulation that occurred in any setting within the hospital and where resuscitation was attempted. A *potentially avoidable* cardiac arrest defined suboptimal practice prior to the event; an *avoidable* arrest defined a clear link with the suboptimal practice and the event. *Hospital admissions* were adult (>15 years) admissions to all areas of the hospital excluding day units and the emergency department (ED). A *critical care* area was coronary care, intensive care, the high dependency unit, or the operating theatres. An *inappropriate clinical area* was defined as a *hospital admission* to a ward not specifically related to the main complaint, or to a general ward where critical care was required. A *delay* in the nurse informing the doctor or the doctor attending was an expert judgement that identified a potential negative impact on the clinical condition that may have been avoided by earlier referral or a more prompt response, irrespective of the absolute time interval.

2.3. Patients and data collection

The records of all adult in-hospital cardiac arrests where resuscitation was attempted for the calendar year 1999 were reviewed retrospectively. Patients designated 'do not attempt resuscitation' (DNAR) and those in cardiac arrest on arrival at the ED were excluded. 139 cases were identified from the switchboard log of CAT activations, and cross-referenced to the established prospective audit of all cardiac arrest cases maintained by the Resuscitation Training Officer, his review of all hospital death case-notes centralised in the Next of Kin office, and his extensive personal network in order to ensure capture of cases should a patient be managed without summoning the CAT. No further cases were identified. Seven cases were excluded without detailed examination of the notes (2 pre-hospital cardiac arrests; 2 peri-arrest rhythms with spontaneous circulation; 1 post-ictal; 1 stridor; 1 case-notes untraceable).

A single investigator (GK) reviewed 132 hospital records. Information on 118 primary cardiac arrests was recorded relating to the patient's demographics, past medical history, admission history, events leading up to the cardiac arrest, and outcome of the cardiac arrest including post mortem diagnoses. Fourteen cases of primary respiratory arrest were identified and ana-

lysed separately. Details were recorded on a standardised form. Face validity of the form was checked (author RC). Content validity was assessed in two stages—first by an independent reviewer who selected and cross-checked 30 sets of records, and second in a pilot study of 6 cases assessed by the panel (see below); this confirmed all essential data had been extracted by the investigator. The pilot study assessed inter-rater reliability, resulting in restructuring of the reviewer decision form. All laboratory findings were tabulated by investigation, date and time. Appended to each case summary were copies of serial electrocardiograms, abnormal radiology reports, and drug therapy charts. Where multiple arrests occurred in an individual in the same admission, only the detailed information regarding the earliest event was recorded (after George et al.) [17].

2.4. Panel review

A panel of four (professor of emergency medicine, consultant in general medicine and cardiology, consultant intensivist, and a resuscitation officer with critical care nursing background) reviewed the detailed case summaries. Panel members were instructed to review all cases independently without discussion, to give an opinion as to whether the cardiac arrest was *avoidable*, *potentially avoidable* or *unavoidable*, and to list reasons for their decision. The definitions and tables of normal values of laboratory markers were provided. Where discrepancies occurred, reviewers were required to seek unanimous or majority agreement through group discussion. For ease of analysis, responses were subsequently collapsed into two groups: *unavoidable* or *potentially avoidable*. Data was stored in a Microsoft Access database developed for the project that conformed to Data Protection legislation regarding patient confidentiality.

2.5. Performance indicators

Eight performance indicators were designed for the study: delay in diagnosis, error in diagnosis, delay by nurses to inform doctor of patient's condition, delay by doctor to respond, failure to respond to abnormal laboratory findings, inadequate response to abnormal laboratory findings, inadequate treatment of clinical condition, and failure to adequately interpret radiographs. Reviewers evaluated each admission with respect to these criteria. They also recorded whether clinical signs of deterioration in the preceding 24 h had been acted upon completely, partially or not at all, and whether a senior member of medical staff (registrar or above) had been consulted.

2.6. Statistical analysis

Results are presented as proportions of cardiac arrests and survival by area. The association between potential avoidability or survival and area (critical vs non-critical) was assessed by the Pearson χ^2 test for contingency table or Fisher's test where appropriate. For a further assessment the odds ratio (OR) and its 95% confidence interval (CI) were also calculated [18,19].

2.7. Study limitations

One member of the review panel (TH) was not independent of the study. There was reliance on a retrospective record where documentation could potentially be incomplete, for example in relation to a doctor attending a patient and making a clinical decision, or a doctor discussing the case with a nurse on the telephone.

3. Results

3.1. Incidence

There were 32 348 adult hospital admissions for 1999. The total number of adult deaths was 1023 (1014 patients died on a ward, and 9 further patients died in the ED). In 905 cases no resuscitation attempt was made (takes account of the one patient with a cardiac arrest secondary to a respiratory arrest, where resuscitation was attempted, and who died), revealing a DNAR rate of 88.5% within the population who died. Specifically, the CAT is mobilised for all patients in this hospital who are found in cardiac arrest unless a DNAR order exists.

There were 118 adult patients with primary cardiac arrest where resuscitation was attempted, of whom 65 (55%) were males. The average age was 72.2 years (median 74.5 and range 22–93 years). Sixteen of 118 patients (14%) survived to hospital discharge.

The primary cardiac arrest rate, excluding DNARs, was 3.8/1000 admissions for all areas (118 cases). When ED was excluded (15 cases), the primary cardiac arrest rate was 3.3/1000 admissions (103 cases). The survival rate of cardiac arrest in hospital admissions was 10% (10/103).

There were 50 954 new adult attendances to the ED, of which 15 ended in primary cardiac arrest, giving an arrest rate of 0.29/1000 attendances. Survival rate for ED arrests was 40% (6/15).

3.2. Location and time

Forty-five percent (53/118) of cardiac arrests were on medical wards, 28/118 (24%) surgical wards, and 22/118 (18%) in critical care areas, and 13% (15/118) in the ED.

Fifty-four percent of cardiac arrests occurred during the day (08:00–20:00 h). There were 75 arrests that occurred during the 260 weekdays and 43 arrests on the 104 weekend days (Saturday or Sunday). The difference between the likelihood of an arrest during a weekday compared to a weekend is significant ($z = 2.3$, $P = 0.02$).

3.3. Avoidability

Following panel discussion there was unanimous agreement that 62% (73/118) of primary in-hospital cardiac arrests were potentially avoidable, and majority agreement that 66% (78/118) were potentially avoidable. For patients admitted to an in-patient area (ED cases excluded), this proportion rose to 68% (70/103) for unanimous agreement and 73% (74/103) for majority decision. The potentially avoidable cardiac arrest rate (majority criterion) for hospital admissions was 2.12/1000.

Table 1 shows the numbers and proportions of potentially avoidable and unavoidable cardiac arrests according to area. There is a highly significant difference between critical care and non-critical care areas (41 and 78%, respectively; $\chi^2 = 15.7$, d.f. = 1, $P < 0.001$). The odds of any cardiac arrest being potentially avoidable in non-critical care areas is more than five times that of critical care areas (OR = 5.1; 95% CI: 2.2, 11.9). All potentially avoidable cardiac arrests in 'critical care' areas occurred in either coronary care (9/16) or the operating theatre (2/4), none occurred in high dependency or intensive care.

Table 2 shows the numbers and proportions of survivors and non-survivors according to area. There is a highly significant difference between critical care and non-critical care areas (32 and 5% survived respectively; $\chi^2 = 16.4$, d.f. = 1, $P < 0.001$). The odds of fatal outcome for patients in non-critical care areas is 9.2 times higher than that of critical care areas (OR = 9.2; 95% CI: 2.7, 31.2).

Table 1
Numbers and proportions of avoidable and unavoidable cardiac arrests according to area (*critical care vs non-critical care*)

	Unavoidable	Avoidable	Total
<i>Area</i>			
Critical	22 59.5%	15 40.5%	37
Non-critical	18 22.2%	63 77.8%	81
Total	40 33.9%	78 66.1%	118

Table 2
Numbers and proportions of survivors and non-survivors according to area nursed (critical care vs non-critical care)

	Survivor	Dead	Total
<i>Area</i>			
Critical	12 32.4%	25 67.6%	37
Non-critical	4 4.9%	77 95.1%	81
Total	16 13.6%	102 86.4%	118

3.4. Appropriateness of clinical area

Seventeen percent (20/118) of cardiac arrests occurred with patients nursed in an inappropriate clinical area. Of all potentially avoidable arrests 24% (19/78) occurred in an inappropriate clinical area. Cardiac arrest was potentially avoidable in 95% (19/20) of those patients nursed in an inappropriate area, while the corresponding proportion for patients nursed in appropriate areas was 60% (59/98). The difference is highly significant (Fisher's exact test $P < 0.002$): in fact, the odds of potentially avoidable cardiac arrest for patients in inappropriate care areas is more than 12 times that of appropriate care areas (OR = 12.6; 95% CI: 1.6, 97.7).

Fifteen of the 20 nursed in an inappropriate area were on a general ward when critical care was required, 8 being acute coronary syndromes managed on a general medical ward. 6/20 were also classified as acute medical patients on a surgical ward (3 cases pneumonia; 1 posterior myocardial infarction; 1 pulmonary embolism; 1 unstable angina post-surgery). Surgical patients on medical wards did not register as a risk, but two 'medical' patients on medical wards who secondarily ruptured their abdominal aortic aneurysms had delayed recognition of protracted haemorrhagic shock.

3.5. Performance indicators

Following panel discussion about the 78 potentially avoidable cardiac arrests there was unanimous agreement regarding failures relating to clinical performance indicators. These are summarised in Table 3.

Seventy-seven percent (60/78) had a delay in diagnosis, and 58% (45/78) had an error in diagnosis. Thirty-five percent (27/78) had a delay by nursing staff to inform the doctor of deterioration. Twenty-nine percent (23/78) had a delay by the doctor to respond to a nurse request to attend. Fifty-eight percent (45/78) had an inadequate response or failure to respond to abnormal laboratory findings. One hundred percent (78/78) had inadequate treatment prior to the arrest. In 24% (19/78) there was a failure in interpretation of radiographs.

Clinical signs of deterioration were considered to have been acted upon partially in 53% (41/78) and not acted upon in 48% (37/78). In 45% (35/78) a house officer was the most senior doctor documented to have reviewed the case in the 24 h preceding arrest.

3.6. Respiratory arrest sub-analysis

Regarding primary respiratory arrests (14 cases), 36% (5/14) survived to discharge. Sixty-four percent (9/14) were classified potentially avoidable (with 2 survivors): of these, all had inadequate treatment prior to the event and 67% (6/9) had failure to respond to abnormal laboratory findings. Other results were delay in diagnosis in 44%, error in diagnosis in 33%, delay by nurse in 33% and delay by doctor in 22%. A description of errors is given in Table 4. Twenty-nine percent (4/14) were nursed in an inappropriate area, and 75% of these were potentially avoidable (unanimous).

3.7. Specific failures

In the 24 h preceding cardiac arrest respiratory rate was recorded in 27% of cases, and oxygen was documented to be given in 41% (20/48) patients who had a documented fall in oxygen saturation ($< 95\%$) by pulse oximetry (SpO₂). Where the fall in SpO₂ was $< 90\%$ only 32% (9/28) were documented to receive oxygen. Arterial blood gases were taken in 58% (34/59) of those with a documented fall in SpO₂.

4. Discussion

The likelihood of potentially avoidable cardiac arrest is greater on a general ward than a critical care area, and is also greater if the patient is nursed in an 'inappropriate' clinical area that does not reflect the needs of the primary condition. Medical patients on surgical wards or patients on general wards rather than critical care areas in part reflects a failure to appreciate the severity of the condition, and in part reflects a high bed occupancy. When the hotel is almost full, the choice of rooms is limited. In such a system a safety net for the vulnerable group of patients is required.

Clinical systems that involve many people and processes will result in gaps in care [20]. Attempts have been made to bridge gaps in the care of the critically ill ward patient by implementation of a *Medical Emergency Team* [11,21], or *Patient at Risk Team* [15]. These types of initiatives have support from the Department of Health [22]. The direction has been towards getting skilled personnel to the bedside, but this is not enough. As the most frequent failure is inadequate treatment it is necessary to ensure that the clinician does the right thing, and follows best clinical practice. It is

Table 3
Trends in performance indicators for potentially avoidable cardiac arrests

Performance indicator	Examples of potential errors (number of events, where ≥ 5)	Comments
Laboratory findings: failure or inadequate response	Poor or absent response to abnormal arterial blood gases (14); abnormal potassium not acted upon (12; 8 of 12 hypokalaemia); abnormal creatinine kinase or troponin-T not acted upon; inadequate response to raised white cell count; inadequate response to acute anaemia	
Delay by nurses to inform doctor	Failure to communicate abnormal vital signs (10); delay in reporting symptoms of myocardial infarction; failure to identify and report symptoms of deep vein thrombosis	
Delay by doctor to respond	<i>Causes could not be identified from data</i>	
Error in diagnosis	Incorrect interpretation of ECG (8; 6 of 8 were missed myocardial infarction); missed pneumonia (5); missed pulmonary embolus (5); missed ruptured abdominal aortic aneurysm; missed deep vein thrombosis; missed hypovolaemia; missed left ventricular failure (2 of 3 treated as pneumonia)	
Delay in diagnosis	Severe hypoxia on pulse oximetry, no blood gases (5); no diagnosis; delay to diagnose myocardial infarction; anaemia cause not identified during 2 days pre-arrest; pulmonary embolism (PE) symptoms not acted upon; delay to diagnose ruptured abdominal aortic aneurysm, AAA; Addisonian crisis not recognised	The PE and AAA are different from the 'Error' group
X-ray interpretation	Missed left ventricular failure, reported by radiologist	
Inadequate management	Inadequate investigation (15); not managed aggressively enough (14); inadequate treatment for hypoxia (12); inadequate treatment of hypovolaemia (6); failure to respond to abnormal vital signs (5); no DVT prophylaxis but pulmonary embolism (5); inadequate treatment left ventricular failure (5) and congestive cardiac failure; delay in thrombolysis; slow treatment of respiratory failure; overload with fluid; inadequate treatment pulmonary embolism; delay to operating theatre; no pacing for complete heart block; poor treatment of bronchopneumonia; no change in pre-admission therapy despite acute event; given IV potassium in renal failure; new spironolactone and new ACE inhibitor in established renal failure; poor anaesthetic management (hasty anaesthetic when dehydrated)	

Two indicators have been combined to produce a failure *or* inadequate response to laboratory findings.

Table 4
Description of errors preceding potentially avoidable primary respiratory arrest

Precipitating condition	Survived to discharge	Potential error(s)
Acute severe asthma	Yes	Failure to ventilate when hypoxic and hypercarbic on blood gases; inadequate drug treatment, not following British Thoracic Society guidelines; failure to act on persistent acute severe symptoms for 24 h; managed on A&E observation ward as no in-patient beds
Fracture neck of femur, post-op	Yes	Delay in temporary pacing for 2nd degree (Mobitz 2) A–V block
Pulmonary oedema, severe hypokalaemia	No	Pulmonary oedema treated as pneumonia (incorrect clinical diagnosis and incorrect interpretation of chest radiograph); inadequate treatment of hypokalaemia
Myocardial infarct	No	Use of vasodilators with aortic stenosis
Left ventricular failure	No	Left ventricular failure treated as pneumonia (incorrect clinical diagnosis; inadequate investigation); hypokalaemia untreated
Pneumonia, probable carcinoma	No	No senior review; incorrect choice of antibiotic
Mesenteric ischaemia	No	Three opiate preparations believed administered concurrently, charting incomplete: potential interaction identified by nursing staff
Left ventricular failure, hyperkalaemia	No	Left ventricular failure treated as pneumonia (incorrect clinical diagnosis and incorrect interpretation of chest radiograph)
Pneumonia, non-Hodgkin's lymphoma	No	Non-invasive ventilation required, but not given; no repeat arterial blood gases; no senior review

Male 8, female 1; mean age 71 years, median 73 years, range 36–92 years.

also important that the criteria to activate the medical response are evidence-based, as current standards are empirical [11,13,14,16].

Our cardiac arrest rate approximates to those published series from the United States (4.0–7.0 per 1000 admissions) [2,3], but in order to compare cardiac arrest rates between hospitals a standardised DNAR policy and register is required together with standard criteria for defining a 'hospital admission'. Our relatively low cardiac arrest rate may be a reflection of the apparently high DNAR rate, although this does not necessarily indicate an incorrect DNAR policy and does not identify those who were DNAR and left hospital alive. DNAR rates are known to be as high as 75–90% [23,24], and can lead to withdrawal or withholding of care [23]. A patient who is designated 'DNAR' may still receive active treatment to prevent arrest, even if resuscitation in the event of an arrest is considered inappropriate. The influence of intensive care resource availability on whether resuscitation is undertaken also needs to be quantified.

Medical errors can be considered as 'active failures' and 'latent failures' [25,26]. We identified a high proportion of active failures (errors of omission) manifest most prominently as failure to follow accepted management pathways for common clinical conditions. Hypoxia and haemorrhage have been identified as leading causes of avoidable death in-hospital following serious injury [27]. The same pathophysiology goes unrecognised in acute medical emergencies. Latent failures constitute the inadequacies of the system. In almost half the cases the most senior doctor known to have

reviewed the patient in the 24 h prior to arrest was a junior house officer. This doctor will often lack the knowledge and experience to deal with medical emergencies, particularly in a system of reduced involvement in acute management in the ED and reduced exposure out of hours. A reticence to seek help from senior colleagues is institutional, but unsupported. Failure of junior doctors to give oxygen to the critically ill hypoxic patient must surely reflect a disproportionate emphasis in medical school of the danger of oxygen therapy in chronic obstructive pulmonary disease. All, or at least most, critically ill patients are dying for oxygen. It is recognised that oxygen may have been given without being documented to those where a low pulse oximetry reading was recorded. The fatal confusion between pneumonia and pulmonary oedema highlights a diagnostic dilemma for the inexperienced. Failure to interpret radiographs is compounded in our system where radiographs are held on the ward during an acute admission and sent for reporting on discharge; radiologist reporting of radiographs during an acute admission is a necessary step to improve this system.

Observers have suggested that avoidable arrest results from a failure to act on clinical information rather than a lack of information [2,3,10,28,29]. Our observed delay of nurses to inform the doctor of deterioration is higher than the 25% previously reported [3]. Failure to administer oxygen or perform blood gases when oxygen saturation is falling on the pulse oximeter implies a failure of observation or a lack of education and experience. Failure to act on abnormal blood gases again may indicate a lack of education and experience,

or reticence to ask for intensivist involvement. The consistent failure to record the respiratory rate loses the opportunity to detect deterioration in ventilation and suggests the need for increased vigilance.

An estimated 100 000 preventable in-hospital deaths occur each year in United States [30], and 33 000 deaths from 'medical accidents' occur annually in the British NHS [12]. While it is recognised that our findings are from one hospital and may not be able to be extrapolated to other institutions, applying our avoidable primary in-hospital cardiac arrest rate (excluding ED events) to 11 million British NHS admissions [31] in 1998–1999 produces a crude annual estimate of the order of 23 000 potentially avoidable events. Survival to discharge from in-hospital cardiac arrest excluding ED events has remained around 15% internationally in the last 25 years [32,33], and is comparable with our survival rates. As outcome is so poor, the emphasis of education and clinical response to in-hospital cardiac arrest must change towards its prevention.

5. Conclusion

A systematic approach to the prevention of in-hospital cardiac arrest is needed. Steps are required to reduce diagnostic error, improve early detection of deterioration, improve activation of appropriate medical resources, and to ensure that clinicians follow established guidelines when they respond. While this provides a safety net, it may not cancel the risk of being unable to place patients in appropriate clinical areas that arises through high bed occupancy.

This study was the first step in an integrated approach to reduce avoidable in-hospital cardiac arrests. The approach has included the development of evidence-based activation criteria, a hospital-wide education programme for doctors and nurses, the development of problem-based guidelines relating to common conditions linked to avoidable in-hospital cardiac arrest, and the implementation of a graded clinical response to deterioration culminating in the activation of a *Medical Emergency Team*.

Clinical governance underlines the responsibility of a hospital to provide quality care. This encourages problems to be identified, and necessitates improvements to be made and results compared with national averages. Each hospital should consider carefully how it must tackle the issue of avoidable cardiac arrest.

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