EDITOR'S CHOICE

Quality of in-hospital cardiac arrest calls: a prospective observational study

Naheed Akhtar,[1,2] Richard A Field,[1] Liz Greenwood,[1] Robin P Davies,[1,2] Sarah Woolley,[1] Matthew W Cooke,[1,2] Gavin D Perkins[1,2]

[1]Heart of England NHS Foundation Trust, Bordesley Green East, Birmingham, UK
[2]University of Warwick, Division of Health Science, Warwick Medical School, Warwick, UK

Correspondence to
Professor Gavin David Perkins; Heart of England NHS Foundation Trust, MIDRU building, Bordesley Green East, Birmingham, B9 5SS
g.d.perkins@warwick.ac.uk

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ABSTRACT

Objective: To determine the quality and diagnostic accuracy of in-hospital adult clinical emergency calls.

Design: Prospective observational study.

Setting: Three National Health Service acute hospitals in England.

Participants: Adult patients sustaining an in-hospital cardiac arrest (CA) or medical emergency (ME) which required activation of the hospital resuscitation team between 1 December 2009 and 30 April 2010.

Main outcome measures: Emergency call duration, emergency team dispatch time, diagnostic accuracy of emergency call (sensitivity/specificity), thematic analysis of emergency call, patient outcomes (return of spontaneous circulation and survival to hospital discharge).

Results: There were 426 adult resuscitation team activations. There was variability in emergency call duration ranging from 6 to 92 s (median 15 s; IQR 12–19). The sensitivity and specificity of calls for a CA was 91% (86.4–94.6%) and 62% (55.5–68.7%), respectively. Sensitivity did not change with call duration but specificity increased from 38% (25.8–51.0%) for the shortest calls to 82% (69.5–89.6%) for longer calls; p=0.03. The return of spontaneous circulation rate was 38% for calls when the patient was confirmed as in CA upon arrival of the resuscitation team. Survival to hospital discharge rates was higher in patients with shorter call durations (26%) than calls with longer call duration (12%); p=0.028. Five themes emerged identifying reasons for the increased call delay.

Conclusion: There is variability in duration and diagnostic accuracy of in-hospital emergency calls. This is associated with delayed activation of the emergency response. The attempt to differentiate between ME and CA is a source of confusion. A single clinical emergency response for CA and ME calls may provide a more focused and timely emergency response.

INTRODUCTION

Approximately 35 000 cardiac arrests (CAs) occur in UK hospitals each year.[1] The first link in the chain of survival emphasises the importance of accurate identification of CA and early mobilisation of the resuscitation team. Evidence from the prospective observational multi-centre registry of in-hospital CA events (the National Registry of Cardiopulmonary Resuscitation (NRCPR)), have shown that the timeliness of the emergency response is critical to patient outcomes.[2 3] Survival is nearly doubled when defibrillation occurs within 2–3 min,[2 4] confirming the time critical nature of the emergency response.

Critical steps in this pathway involve the correct diagnosis of CA and prompt activation of a resuscitation team. In-hospital cardiopulmonary resuscitation (CPR) studies have shown that there are distinctive signs of clinical deterioration in the 6–8 h preceding the event,[2 5 6] therefore there is a window of opportunity to intervene earlier and potentially prevent CA and improve patient outcome. In 2007, The National Institute for Health and Clinical Excellence published clinical guidelines for the recognition of and response to acute illness in adults in hospital.[7] These require National Health Service (NHS) hospitals to provide a tiered response to the acutely ill patient. An immediate response is required for the most critically ill patients by a team with critical care competencies and diagnostic skills, advanced airway management and resuscitation skills. Many hospitals in the UK use a model whereby a single team responds to reports of medical emergencies and CAs. The teams are activated through a standardised

emergency telephone number (2222).[8] Emergency calls are received by the hospital switchboard operator who then activates the emergency team through an emergency pager system. Research from out-of-hospital settings has shown that the quality and diagnostic accuracy of emergency calls for CA are variable.[9] However, to our knowledge, this has not been measured for in-hospital emergency calls. The aim of this study is to determine the quality and diagnostic accuracy of emergency 2222 calls, to understand the reasons for time delays and to explore the relationship between call duration and patient outcomes.

METHODS

Approvals

The study forms part of the National Institute for Health Research (NIHR) for Patient Benefit funded Quality of CPR Improvement Initiative. The study received ethical approval from the Coventry and Warwickshire Research Ethics Committee (Ref. 09/H1210/65). The ethics committee waived the requirement for patient consent.

Setting

This study was a prospective observational study conducted in three NHS hospitals within a single NHS Trust in the UK. The Heart of England NHS Foundation Trust is one of the largest acute hospital trusts in England, with over 1400 beds across three NHS hospitals (Heartlands, 667 beds; Good Hope, 511 beds; Solihull, 255 beds). Patients are monitored for evidence of clinical deterioration using a modified early warning score.[10] The trust provides a tiered response for patients identified as being at risk of clinical deterioration.[7] Patients identified at low risk of deterioration are assessed by ward staff. Patients identified at medium risk are referred to the treating clinician's team and nurse-led critical care outreach team.[11] An emergency team is called to patients identified at either high risk of deterioration or those deemed at imminent risk of cardiac or respiratory arrest (defined as a medical emergency) or those that sustain a cardiac/respiratory arrest. Each hospital site has a clinical emergency team which responds to adult CA and medical emergency (ME) calls.[1] Each team comprises one or two junior doctors, a critical care doctor (with advanced airway management skills), a critical care outreach nurse, the senior sister on duty and a hospital porter. The minimum standard of training for team leaders is Resuscitation Council (UK) Advanced Life Support (ALS) training;[12 13] the minimum standard for team members is Resuscitation Council (UK) Immediate Life Support (ILS) training.[14] Upon arrival the team will assess the patient's vital status and initiate appropriate emergency treatment.

Emergency call procedure

All ME and CA calls are handled through a central switchboard. All calls are digitally recorded and archived to allow later review. In the event of an in-hospital emergency, staff can activate the emergency team by dialling the dedicated emergency call number, 2222. This number is a priority line which is answered immediately by the switchboard operator. Callers must state which hospital site, the nature of the emergency (CA or ME) and location within the hospital. In the event that incomplete information is provided or the operator is uncertain, the operator will interrogate the caller to obtain the required information. The operator then confirms with the caller the site, nature and location of the event.

Once this process is completed the operator activates the emergency pager system. This temporarily suspends transmission of all other pager transmissions and prioritises dispatch of the emergency call. The operator records a voice message stating the nature of the emergency, location and hospital site. This is transmitted to dedicated emergency voice pagers (Blick Communications Ltd, Stanley Security, Swindon, UK). The time of the emergency call receipt, call duration and emergency pager activation time are recorded automatically on computer systems located at the switchboard. The emergency pager system is tested every 24 h to confirm that it is in working order.

Inclusion criteria and data collection

The emergency telephone call recording system (Voice Print International, VPI, Inc., Camarillo, California, USA) was used to identify emergency calls between 1 December 2009 and 30 April 2010. All calls made to the central hospital emergency line (2222) were reviewed. Calls relating to adult CA or ME were eligible for inclusion. Calls describing a non-clinical incident (eg, fire, security emergency) or referring to paediatric, neonatal emergency department incidents were excluded as these events are not attended by the hospital adult resuscitation team. Calls were reviewed independently by NA and RF. Data on the time and date of the emergency, time variables, nature of the emergency (CA or ME), site and location were extracted. Time variables collected were call duration (time from call being placed to end of call), operator processing time (time from end of call to initiation of pager message) and system time (time from operator placing emergency call to message being transmitted to pagers). All times were calibrated to the universal time coordinated clock.

Actual event data, return of spontaneous circulation, (ROSC) and survival to hospital discharge were retrieved from the local in-hospital CA registry, which forms part of the National Cardiac Arrest Audit scheme. At the end of each call the operator confirms the nature of the event with the caller. This determines if the emergency

call is transmitted to the team as a ME or CA. The patient status upon arrival of the emergency team was regarded as the gold standard for the calculation of sensitivity and specificity.

Cardiac arrest was defined by the requirement for chest compressions and/or defibrillation; ME by evidence of physiological instability or requirement for urgent treatment. False alarm was recorded when after careful patient assessment there was no evidence of physiological instability or requirement for urgent treatment. These data were obtained from the CA database. Data are directly entered into the CA database via personal digital assistants held by clinical staff in attendance at the emergency event. Inbuilt logic tests within the software application combined with triangulation with clinical records ensure this is a reliable data source. Periodic re-abstraction of data confirms an error rate of <1% for the nature of the emergency. Data from the two reviews were compared and any cases of disagreement (occurred in <1%) were re-reviewed and agreement obtained on the correct classification.

Statistical analysis

Data were entered into a Microsoft Windows Excel spreadsheet (Microsoft, Las Vegas, Nevada, USA) and analysed by SPSS V.18.0 (SPSS Inc., Chicago, Illinois, USA). Emergency call duration, operator/system processing call time and total call time were divided into quartiles according to initial call duration. Data were analysed using descriptive statistics and expressed as medians, with IQR (lower quartile–upper quartile) points in parentheses. The diagnostic performance of calls across each quartile were assessed by calculating sensitivity (the number of calls correctly designated by the operator as CA, divided by the total number of CAs upon arrival of the resuscitation team) and specificity (the number of calls correctly designated by the operator as ME divided by the number of MEs attended by the resuscitation team). The estimates of diagnostic test accuracy are expressed as a point estimate of sensitivity and specificity with 95% CIs. A χ^2 test was used to test the differences between categorical variables. One-way analysis of variance was used to evaluate differences among call duration quartiles. Results were considered significant if p value <0.05.

Qualitative analysis of calls

Calls in the fourth quartile (those of the longest duration) were retrieved and subject to a qualitative analysis to identify reasons for the increased call delay. Calls were transcribed verbatim into a Word document (Microsoft). A qualitative thematic analysis was performed to categorise emergency calls. Manual coding was carried out by marking and highlighting the passages of text that were about the same concept. Once the data had been transcribed and data extracts coded, the aim was to sort or categorise all the identified codes into groups to search for themes. Each coded data extract that had been categorised under a particular theme was reviewed to check for consistency and that it formed a coherent pattern when all data extracts were taken together. Once a thematic map had been developed the essence of what each theme displayed was considered to give the theme a name.

RESULTS

Four hundred and twenty-six clinical adult emergency calls were made between 1 December 2009 and 30 April 2010. Call durations ranged between 6 and 92 s with a median (IQR) of 15 s (12–19 s). The average call duration of CA calls and ME calls were 15 s (SD 5.62) and 20 s (SD 10.90), respectively (p<0.0001). After completion of the call it took an average of 57 s to activate the emergency pager system; this comprised an average operator processing time of 25 s and system processing time (communication call system activation and transmission time) of 32 s. The breakdown of call durations divided into quartiles is given in table 1. There was a significant difference between the different call duration quartiles (p=0.001). There was no difference in operator processing time between the different quartiles of call duration. Total call time (call duration +operator/system processing time) differed significantly among the four quartiles (p=0.001).

Table 1 Emergency calls duration, response times and diagnostic accuracy divided into quartiles according to initial call duration

Group number	Quartile 1 6–12 s	Quartile 2 13–15 s	Quartile 3 16–19 s	Quartile 4 20–92 s
Number of 2222 calls (n)	136	100	93	97
Call duration (s)*	11 (10–12)	14 (13–15)	17 (16–18)	24 (21–29)
Operator/system processing time (s)*	50 (36–73)	53 (38–77)	52 (37–74)	51 (38–77)
Total call time (s)*	60 (47–83)	67 (52–91)	71 (56–92)	79 (64–104)
Sensitivity (%)	91 (82.5–96.6)	86 (73.2–93.2)	100 (90.2–100)	85 (67.3–94.2)
Specificity (%)	38 (25.8–51.0)	61 (45.5–75.2)	70 (53.6–80.9)	82 (69.5–89.6)

*Data are median (IQR).

Accuracy of calls

A total of 272 (64%) calls were described by the caller as CA calls and 154 (36%) were described as ME calls. Upon arrival of the emergency team 208 (49%) cases were CA, 168 (38%) were ME and 50 (12%) were false alarms. Overall the sensitivity and specificity of calls for a CA was (190/208) 91% (86.4%–94.6%) and (136/218) 62% (55.5%–68.7%), respectively. There was no significant difference in sensitivity among different call duration quartiles. Specificity increased according to call duration from (23/61) 38% (25.8%–51.0%) for the shortest calls (quartile 1) to (53/65) 82% (69.5%–89.6%) for longer calls (quartile 4) (p=0.03).

Patient outcomes

For the 191 CA calls for which patients were confirmed as in CA upon arrival of the resuscitation team, the ROSC rate was 38%. There is no difference in ROSC rates between shorter calls (quartiles 1 and 2: ROSC 49/116, 42%) and longer calls (quartiles 3 and 4: ROSC 24/75, 32%) (p=0.282). Survival to hospital discharge rates was higher in patients with shorter call durations with survival at 26% (30/116) compared with 12% (9/75) for calls with longer call duration (p=0.028).

Qualitative analysis of prolonged calls

There were 97 calls in quartile 4 with call durations of 20–92 s. Qualitative analysis of call content identified 10 categories. Examples are provided in table 2. From the 10 categories, five themes were identified and associated with delayed emergency response. The theme 'irrelevant detail' included three categories: the caller providing unnecessary information, for example, the patient's name (9/97, 9%), the patient's clinical condition (35/97, 36%) and incident description (3/97, 3%). The second theme was 'incorrect terminology' (14/97, 14%), such as peri-arrest, crash call, arrest and ventricular tachycardia arrest. The third theme, 'speech' included three categories: accent (4/97, 4%), fast talking (6/97, 6%) and hesitancy/ faltering speech (10/97, 10%). The fourth theme 'location of emergency' comprised two categories: difficulty in describing location of arrest in a non-clinical area (12/97, 12%) and unnecessary repetition of location (10/97, 10%). The fifth theme, 'uncertainty of nature of emergency', included two categories for which the caller had to go and retrieve the nature of the emergency from the source provider (5/97, 5%) and was unsure about the nature of the emergency (9/97, 9%).

DISCUSSION

This study identified variability in the quality, duration and accuracy of in-hospital clinical emergency calls. Calls with longer durations were associated with delayed activation of the emergency team. Although the specificity (correct identification of patients not in CA) improved with increasing call durations, it had no impact on sensitivity (correct identification of patients in CA). There was an association with poorer outcomes among patients in whom the initial emergency call was prolonged.

The chain of survival describes a stepwise process of care designed to optimise outcomes from CA. It comprises four links—early recognition of deterioration and activation of the emergency team, early CPR, early defibrillation and effective post-resuscitation care.[15 16] Although initial resuscitation attempts are usually started by clinical staff at the site of the CA, resuscitation in most hospital settings is continued by a multi-professional resuscitation team. While uncertainty remains over the effectiveness of automated external defibrillators in hospitals,[17 18] the prompt recognition of CA and effective systems to dispatch the resuscitation team remains a central step in the resuscitation process.

The time critical nature of interventions in CA has been demonstrated in a number of studies. Data from out-of-hospital CAs indicate that for each minute defibrillation is delayed in the treatment of ventricular fibrillation/ventricular tachycardia, the likelihood of survival decreases by approximately 10%.[19 20] Analysis of data from a large in-hospital CA registry identified improved outcomes in patients receiving defibrillation within 2 min of collapse (39.3% vs 22.2%). Chan *et al* sought to identify the factors associated with the delays in defibrillation by exploring data from 200 hospitals.[21] While hospital size and arrest location were contributory factors, most variation remained unexplained. The finding in the present study of wide disparity in the duration of in-hospital emergency calls ranging from 10 s to over 90 s may be a source of such variation. Longer calls led to delayed activation and dispatch of the emergency team and were associated with worse patient outcomes. This observation does not imply a causal relationship as unmeasured patient, caller or system factors may be confounding factors causing longer call durations. However, it is appropriate to further scrutinise such wide variability in a relatively simple clinical process variable.

In 2004, the Institute for Healthcare Improvement challenged the healthcare system with its 'Saving 100 000 Lives Campaign' to implement change to improve quality of care and the timeliness of healthcare delivery.[22] One of the initiatives was the introduction of Rapid Response Systems, typified by medical emergency teams and rapid response teams (RRTs). RRTs have recently been implemented in many hospitals worldwide and recommended as a patient safety measure. Several

Table 2 Themes and examples from longest calls (quartile 4) illustrating the caller not conforming to the requirements of the standardised emergency protocol

Theme	Category	Frequency	Example
Irrelevant detail n=47	Patient name	9	Caller (asking colleague): "Who is it?"
	Clinical condition	35	Operator: "Emergency, which site?"
	Incident description	3	Caller: "(asking colleague Who)…(pause 00:00:00–00:00:05)… I'm calling from ward X, we have got an emergency, one moment, trying to find out who it is…pause…Mr. ****…"
			Operator: "Yeah but what kind of an emergency?"
			Caller: "but…one moment (pause 00:00:00–00:00:06) Mr ****"
			Operator: "I don't need patients name, is it a cardiac arrest or medical emergency?"
			Caller: "…Cardiac arrest, yeah…"
			Operator: "So you have a cardiac arrest, ward X hospital A. Thank you."
			Call duration: 40 s
Speech n=20	Accent	4	Operator, "Emergency, which site?"
	Fast talking	6	Caller: "Arrest in endoscopy, outside. Porter just say that."
	Hesitancy	10	Operator: "Cardiac arrest in endoscopy, is that what you are saying?"
			Caller: "Yes."
			Call duration: 22 s
Incorrect terminology (n=14)		14	Operator: "Emergency, which site?"
			Caller: "Hospital A, ward X."
			Operator: "What is happening?"
			Caller: "Arrest, peri-arrest."
			Operator: "Do I have to say peri-arrest?"
			Caller: "Oh no it's a cardiac arrest."
			Operator: "Hospital A, cardiac arrest, ward X."
			Caller: "Thank you, bye."
			Call duration: 21 s
Location of emergency n=22	Difficulty describing location in non-clinical area	12	Operator: "Emergency, which site?"
			Caller: "err…Hospital A."
			Operator: "What is the matter?"
	Unnecessary repetition of location	10	Caller: "A man has fallen over outside of our Ward X."
			Operator: "So is it a medical emergency?"
			Caller: "Yeah."
			Operator: "Outside ward X."
			Caller: "Yes, by X X."
			Operator: "Outside by? So is it outside the doors?"
			Caller: "I can see him through the windows, there are some people with him, erm but he needs an ambulance. I don't know any other details."
			Operator: "Ok, medical emergency so its outside the doors by ward X, shall I say that?"
			Caller: "No, it's just by X X."
			Operator: "Ok, by X X, thank you."
			Call duration: 42 s
Uncertainty about nature of emergency n=14	Retrieve nature of emergency from source provider	5	Operator: "Emergency, which site?"
			Caller: "Hello, ward XX, Hospital A please."
			Operator: "What have you got?"
	Unsure about nature of emergency	9	Caller: "I think it is a cardiac arrest."
			Operator: "You think or is it a cardiac arrest?"
			Caller: "Hold on 1 min, 1 min (00:00:11 – 00:00:25)…hello?…yes it is a cardiac arrest."
			Operator: "Cardiac arrest, thank you."
			Call duration: 31 s

single-centre studies to date have shown an association between implementation of Rapid Response Systems and improved hospital outcomes.[23–26] However, some trials have not shown any improvement in outcomes.[27–30]

In this study the overall initial survival rate was 38%, which is similar to national rates previously reported.[2 31] Given the equivocal evidence and heterogeneity observed across published studies in support of the effectiveness of RRT programmes, in particular, the largest randomised controlled trial,[27] which found no significant improvements in favour of implementing RRTs, it remains unclear whether the potential benefit actually derives from RRT intervention or from education of staff on how to better recognise deteriorating patients earlier. The symbiotic relationship between timely recognition of a patient's clinical deterioration and a rapid response system work towards improving patient outcomes; however, further evaluation is required to determine the effectiveness of RRTs. We strongly recommend a critical review and evaluation of the current practice of unnecessary differentiation between CAs and MEs, which may reduce delays in team activation with a subsequent impact on patient mortality.

The National Institute for Health and Clinical Excellence requires NHS hospitals to have systems in place to deliver a tiered response for patients identified as being at risk of clinical deterioration.[7] Patients identified at low and intermediate risk of deterioration are typically cared for by ward-based staff or a nurse-led critical care outreach team.[11] Patients at the more critical end of the spectrum are attended by a ME team. The clinical and cost effectiveness between these two differing models remain to be determined.

Wide heterogeneity in the quality and diagnostic accuracy of emergency calls for victims of out-of-hospital CAs has been observed. This is perhaps not unexpected as the emergency call operator must effectively interrogate bystanders often with little or no healthcare experience. Although standardised, protocol-driven call dispatch systems improve diagnostic accuracy, sensitivity remains around 75%.[32 33] Factors influencing the diagnostic accuracy of out-of-hospital CA calls may include the presence of agonal breathing,[34] language difficulties[35] and seizures.[36] To our knowledge, this study is the first to highlight the diagnostic accuracy of calls for in-hospital CAs. Although sensitivity was higher than that reported for out-of-hospital CAs, there was variability in specificity, with shorter calls being less reliable for excluding the presence of a CA. However, in this setting where the same clinical emergency teams are dispatched for both CAs and medical emergencies, there is little to gain from improving specificity or indeed seeking to differentiate between these two diagnoses. Linked to this concept, three of the five themes identified in the qualitative review of prolonged calls ('irrelevant detail', 'incorrect terminology' and 'uncertainty about nature of emergency') may be eliminated by introducing a single clinical emergency response (figure 1).

There are a number of limitations to this study. First, data were obtained from only three hospitals which form part of a single healthcare organisation. Although the organisation adheres to national guidelines for managing the emergency response to a patient who is acutely deteriorating or has arrested, the reproducibility of these findings across both local and international healthcare organisations is a matter for speculation. Second, as it was not possible to measure the arrival of the emergency team, the link between call duration and arrival of the emergency team is inferred. Similarly, the observation that survival to discharge was worse in patients with prolonged call durations cannot claim to be causal as other staff, patient or system factors may be confounders. Despite these limitations, this study highlights an area of practice not previously examined in the hospital-based response to CA. These findings should act as a prompt for healthcare systems to scrutinise their performance and explore the impact of streamlined call-handling procedures on process and patient-focused outcomes.

In conclusion, this study illustrates variability in duration and diagnostic accuracy of in-hospital emergency calls. This is associated with delayed activation of the emergency response. The attempt to differentiate between ME and CA calls is a source of confusion and leads to delays and variation in the length of calls. A

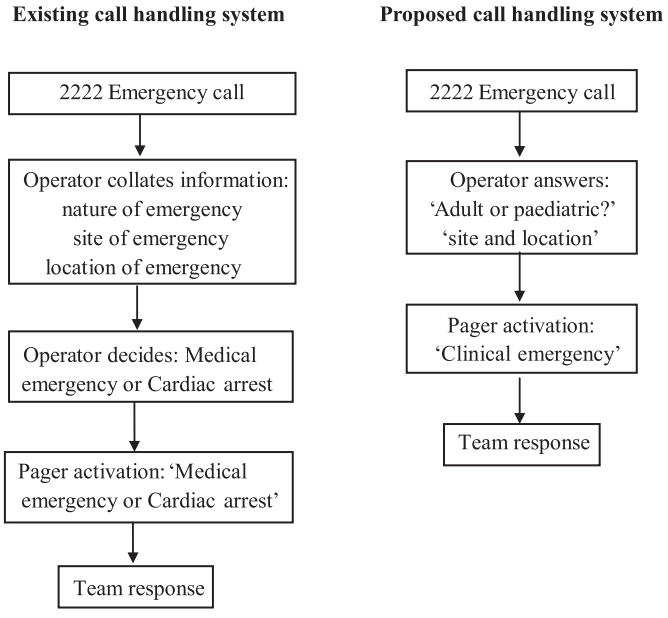

Figure 1 Proposed schematic model for a call-handling system illustrating potentially improved emergency team response.

single clinical emergency response for CA and ME calls may provide a more focused and timely emergency response.

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Ethics approval Coventry Research Ethics Committee, UK.

Contributor GDP, MWC, RPD and SW conceived the study and contributed to study design. NA, LG and RF contributed to study design. NA analysed the data and produced the first draft of this paper. All authors contributed to the critical appraisal and revision of the paper and approved the final version. GDP acts as guarantor.

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