Resuscitation 109 (2016) 56–63

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Factors impacting upon timely and adequate allocation of prehospital medical assistance and resources to cardiac arrest patients

Camilla Hardeland[a,b,*], Kjetil Sunde[a,c], Helge Ramsdal[d], Susan R. Hebbert[e], Linda Soilammi[f], Fredrik Westmark[g], Fredrik Nordum[b,h], Andreas E. Hansen[f], Jon E. Steen-Hansen[e], Theresa M. Olasveengen[b,c]

[a] Institute of Clinical Medicine, Faculty of Medicine, University of Oslo, PB 1171 Blindern, N-0318 Oslo, Norway
[b] Norwegian National Advisory Unit on Prehospital Emergency Medicine, Oslo University Hospital, PB 4956 Nydalen, N-0424 Oslo, Norway
[c] Department of Anaesthesiology, Division of Emergencies and Critical Care, Oslo University Hospital, PB 4956 Nydalen, N-0424 Oslo, Norway
[d] Department of Health and Social Studies, Østfold University College, PB 700, 1757 Halden, Norway
[e] Prehospital Clinic, Vestfold and Telemark Emergency Medical Communication Centre, Vestfold Hospital Trust, PB 2168, NO-3103 Tønsberg, Norway
[f] Prehospital clinic, Oslo Emergency Medical Communication Centre, Oslo University Hospital, PB 4956 Nydalen, N-0424 Oslo, Norway
[g] Prehospital Clinic, Østfold HF Hospital Trust, PB 300, NO-1714 Sarpsborg, Norway
[h] Prehospital clinic, Oslo University Hospital, PB 4956 Nydalen, N-0424 Oslo, Norway

ARTICLE INFO

Article history:
Received 4 July 2016
Received in revised form 1 September 2016
Accepted 28 September 2016

Keywords:
Emergency medical dispatch
cardiac arrest
cardiopulmonary resuscitation
cpr
emergency medical communication centre
dispatcher
dispatchers
mixed-methods

ABSTRACT

Aim: Explore, understand and address issues that impact upon timely and adequate allocation of prehospital medical assistance and resources to out-of-hospital cardiac arrest (OHCA) patients.
Methods: Mixed-methods: design obtaining data for one year in three emergency medical communication centres (EMCC); Oslo-Akershus (OA), Vestfold-Telemark (VT) and Østfold (Ø). Data collection included quantitative data from analysis of dispatch logs, ambulance records and audio files. Qualitative data were collected through in-depth interviews and non-participant observations.
Results: OA-, VT- and Ø-EMCC responded to 1095 OHCAs and 579 of these calls were included for further analysis (333, 143 and 103, respectively). There were significant site differences in their recognition of OHCA (89, 94 and 78%, respectively, $p < 0.001$), provision of CPR instructions (83, 83 and 61%, respectively, $p < 0.001$), time from call answered to initial CPR instructions (1.4 min (1.2, 1.6), 1.1 min (0,9, 1.2) and 1.3 (1.2, 1.7) respectively, $p = 0.002$). The most frequent reason for delayed or failed recognition of OHCA was misinterpretation of agonal breathing. Interviews and observations revealed individual differences in protocol use, interrogation strategy and assessment of breathing. Use of protocol was only part of decision making, dispatchers trusted their own clinical experience and intuition, and used assumptions about the patient and the situation as part of decision making.
Conclusion: Agonal breathing continues to be the main barrier to recognition of cardiac arrest. Individual differences among dispatchers' strategies can directly impact on performance, mainly due to the wide definition of cardiac arrest and lack of uniform tools for assessment of breathing.

Introduction

Patient outcomes depend on emergency medical dispatchers' ability to rapidly recognise out-of-hospital cardiac arrest (OHCA) and offer cardiopulmonary resuscitation (CPR) instructions to bystanders. If a dispatcher recognise cardiac arrest, victims are more likely to receive bystander CPR improving their chance of survival.[1–4] While current guidelines emphasise the importance of emergency medical communication centres (EMCC) with the dispatcher as an essential link in the chain of survival,[5,6] the International Liaison Committee (ILCOR) consensus on science highlights substantial knowledge gaps about dispatcher training and EMC centre configuration.[5]

The American Heart Association (AHA) published a scientific statement advocating quality assurance and monitoring of key quality indicators like recognition of OHCA, provision of CPR

* Corresponding author. Fax: +47 22844651.
E-mail address: camilla.hardeland@medisin.uio.no (C. Hardeland).

http://dx.doi.org/10.1016/j.resuscitation.2016.09.027
0300-9572/

instructions and important time intervals.[7] However, large variations in quality among published studies exist, with recognition of arrest between 56-98% and time to first chest compression between 2,9 and 4,8 minutes.[3,8–12] There is limited insight into reasons for this variation.

During the 90s, lay rescuer education and training gradually removed the use of carotid pulse check to identify cardiac arrest, and assessment of breathing became increasingly emphasised.[13–16] Experience from EMC centres suggested untrained bystanders could identify cardiac arrest by assessing whether a person was unresponsive and in respiratory arrest.[17] Widespread implementation of new CPR training courses following 2000 AHA and 2001 European Resuscitation Council (ERC) guidelines abandoned pulse checks for lay rescuers, and cardiac arrest was defined as an unresponsive person with no or abnormal breathing.[18,19] Due to these guideline changes, many efforts have been made to describe and address the issue of abnormal or agonal breathing during cardiac arrest.[20,21] Nonetheless, agonal breathing remains the single most challenging barrier to recognise cardiac arrest.[10,21–24] Better clinical support tools are needed to ensure optimal handling of all cardiac arrest calls.

The aim of this study was to explore, understand and address issues that impact upon timely and adequate allocation of prehospital medical assistance and resources to OHCA patients.

Methods

This is a descriptive and exploratory study with mixed-method design using both quantitative and qualitative research methods: The study explores factors and issues impacting on emergency medical dispatchers behaviour and response in cardiac arrest situations.

We evaluated dispatcher performance at three representative Norwegian EMC centres; Oslo-Akershus, Vestfold-Telemark, and Østfold. All norwegian EMC centres are staffed by registered nurses and emergency medical technicians/paramedics. They use the same decision support tool; Norwegian Index for Emergency Medical Assistance,[25] with some local variations. This "Norwegian Index" is criteria based and uses guidelines with prompts based on caller descriptions of signs and symptoms to provide direction and assistance in defining appropriate levels of care. The cardiac arrest protocol recommended during the study period prescribed in the presence of a presumed cardiac cause, chest compression only CPR the first 10 minutes moving to standard CPR with compression: ventilation (30:2). If presumed respiratory or traumatic cause, standard CPR was recommended from the beginning.

Based on appropriate qualitative research recommendations we used a purposive sampling method, selecting information rich cases for in-depth study.[26] Maximum variation purposive sampling aims to capture and describe central themes cutting across a great deal of variation. Common patterns emerging from great variation are of particular interest. Value is placed on capturing core experiences and central, shared dimensions of a setting or phenomenon.[26] Maximum variation was captured by: (1) Location: metropolitan vs. non-metropolitan/remote, (2) Size: large vs. smaller population served as well as large vs. smaller geographical area covered, and (3) Organisation of Emergency Medical Service (EMS) system – dispatchers working only with dispatch vs. dispatchers rotating through ambulance or emergency room shifts. This reflects a balance between obtaining in-depth rich data within centres as well as being able to compare centres. The study was conducted in accordance with the Declaration of Helsinki incorporating principles of informed consent, right to withdraw and anonymity.[27] Exception from confidentiality was approved by the regional research ethics committee (Reference no. 2012/1611 A).

EMC centres (Table 1)

Oslo and Akershus EMCC (OA-EMCC)

OA-EMCC is part of the Oslo University Hospital (OUH). OA-EMCC covers the regions of Oslo, Akershus and Rømskog consisting of both rural and urban areas and a population of 1,2 million people. In 2013 OA-EMCC received approximately 315 000 calls of which approximately 124 000 were emergency calls. The region has 45 regular ambulances at its disposal in addition to one single paramedic manned ambulance, one motorcycle unit, and one physician staffed rapid response vehicle. In addition, OA-EMCC is responsible for two physician staffed helicopters. OA-EMCC employs 25 emergency medical technicians (EMTs)/paramedics coordinating ambulance responses and 29 registered nurses answering emergency calls.

Vestfold-Telemark EMCC (VT-EMCC)

VT-EMCC serves a population of approximately 400,000, and deploys 31 ambulances at 15 stations. It is staffed by registered nurses with additional training in emergency medical dispatch answering emergency calls, and EMTs/paramedics coordinating ambulance responses. The VT-EMCC has on-site training in telephone triage and dispatch, and keeps the staff professionally updated with regular courses and training days. In 2013 they responded to 32,776 emergency calls and handled a total of 63,025 calls, resulting in 47,486 ambulance assignments. VT-EMCC uses a locally designed protocol with reduced opening lines and specific key words for OHCA suspicion. Instructions in CPR for adults recommend compression-only CPR for all OHCAs except those with hypoxia or trauma.

Østfold EMCC (Ø-EMCC)

Ø-EMCC is operated by Østfold Hospital Trust and covers a population of 287, 000 people. It deploys 23 ambulances, and delivers emergency and non-emergency services to the cities and nearby communities. Ø-EMCC is staffed by registered nurses with additional EMCC training answering emergency calls, and EMTs/paramedics coordinating ambulance responses. The nurses rotate between work in the dispatch centre and as clinical nurses in the emergency room. Ø-EMCC employs 21 dispatchers each responding to an average of eight OHCA calls annually. Ø-EMCC handles almost 110 000 calls per year, respond to approximately 42 000 calls of which approximately 28 000 are emergency calls.

Collection of quantitative data

All consecutive adult OHCA calls during a one-year period in the three different study sites were registered, from Jan 28th 2013 to Jan 31st 2014, from Jan 1st 2013 to Dec 31st 2013, and April 1st 2013 to Mar 30th 2014, at the OA-EMCC, VT-EMCC, and Ø-EMCC, respectively. OHCA cases were identified from respective cardiac arrest registries and digitalised recordings were audited. Key indicators included clarification of consciousness and normal breathing, recognition of OHCA and incidence of pre-arrival instructions with appropriate time intervals. Additional information was obtained from ambulance and dispatch records. The following cases were excluded:

- patients where ambulance personnel either witnessed the arrest or decided not to start CPR due to futility
- patients not in cardiac arrest at time of call
- caller not with patient
- cases without need for CPR instructions (health care facility or on-going CPR)
- calls interrupted before recognition of cardiac arrest was possible
- cases with missing/corrupted audio files.

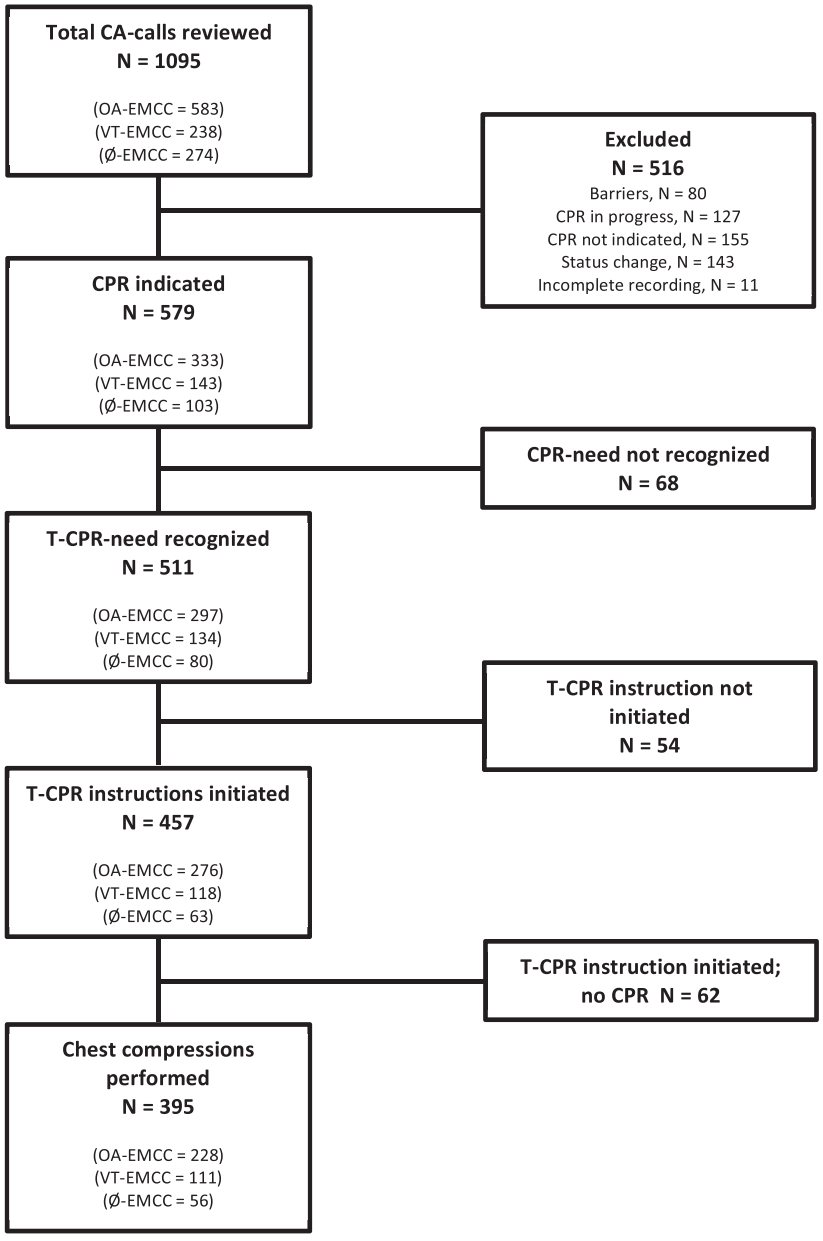

Fig. 1. Inclusion criteria.

Cardiac arrest was classified as *"recognised"* by the dispatcher when one of the following criteria was met: 1) CPR instructions offered, 2) documented as cardiac arrest in dispatch chart or 3) cardiac arrest was unmistakably described by person with patient, but CPR instructions were not offered due to circumstances at scene. "*Delayed recognition"* was defined as failure to initially clarify consciousness or abnormal breathing before moving on to further questioning regarding other symptoms or patient history. Absence of normal breathing was classified as clarified if the dispatcher recognised cardiac arrest or asked specifically if the patient was breathing normally.

Statistical analysis

Statistical calculations were performed using a spreadsheet program (Excel 2010, Microsoft Corp, Redmond, WA, USA) or a statistical software package (SPSS 22.0, SPSS Inc., Chicago, IL, USA). Values are given as numbers with percentages or medians with 95% confidence intervals. Categorical data were analysed using Pearson chi-squared test. Comparisons of continuous data were done with non-parametric Independent-Samples Kruskal-Wallis Test. P-Values ≤ 0.05 were considered significant.

Collection of qualitative data

Non-participant observations. We performed on-stage non-participant observations[28,29] at the three EMC centres. The researcher did not interact with the staff (unless directly approached) and was placed at a distance from the activities being investigated,[30] although reflective conversations in-between took place to clarify aspects of what was observed.[26] Observations focused on physical surroundings, interactions with and between dispatchers, work load and intensity and use of protocols.[31,32] A special designed system was developed for data collection following principles from the observational methodology literature.[30]

In-depth interviews. Calls believed to be information-rich representing all three categories (*arrest recognised, not recognised* and *delayed recognition*) were identified and corresponding dispatchers were asked to participate in an interview. Nineteen in-depth interviews addressed challenges and difficulties in daily work to identify positive and negative factors affecting the delivery of what was considered "optimal" treatment. In particular, the interviews focused on three themes: (1) the selected cardiac arrest case and cardiac arrest calls in general, (2) the use of relevant protocol and (3) contextual conditions, such as work environment (social and physical), work load, organisational factors and leadership. All interviews were digitally recorded and transcribed verbatim. To ensure consistency and rigor the analytical process was iterative and involved several readings of the data and discussions between the first author (CH) and co-authors (TMO, HR, KS). Data from the in-depth interviews were analysed thematically drawing on principles of Malteruds Systematic text condensation.[33] Hyper Research 3.7.3 Computer Software, Researchware, Inc., 2015 was used to organise the transcribed text.

Results

Quantitative description of OHCA

The three EMC centres (OA-, VT- and Ø-EMCC) responded to 1095 OHCAs during the study period, and 579 of these calls were included for further analysis (333, 143 and 103, respectively) (Fig. 1). The three systems are described in Table 1. There were significant site differences in their adherence to algorithm (clarification of consciousness and normal breathing) (90, 96 and 72%, respectively, $p < 0.001$), recognition of cardiac arrest (89, 94 and 78%, respectively, $p < 0.001$) and provision of CPR instructions (83, 83 and 61%, respectively, $p < 0.001$). The most frequent reason for delayed or failed recognition of cardiac arrest was misinterpretation of agonal breathing (Table 2).

The three sites had different median time intervals (95% confidence interval) from call answered to dispatch of ambulance (0.6 min (0.5, 0.7), 0.5 min (0.5, 0.6) and 0.9 min (0.7, 1.0), respectively, $p < 0.001$) and from call answered to initial CPR instructions (1.4 min (1.2, 1.6), 1.1 min (0,9, 1.2) and 1.3 (1.2, 1.7) respectively, $p = 0.002$). There were no significant differences in time to chest compression instructions or performance of actual chest compressions (Table 3).

Analysis of interviews

After initial read-throughs of all material to establish an overview of the data, we identified 14 themes concerning recog-

Table 1
Study sites overview.

	OA-EMCC	VT-EMCC	Ø-EMCC
Population	1 200 000	372 000	282 000
Area	5555 km^2	12 137 km^2	4182 km^2
Dispatchers employed	29	14	11
EMT/paramedics employed	25	11	10
Staff on duty daytime	4 dispatchers 3 EMT/Paramedics	2 dispatchers 2 EMT/Paramedics	1 dispatcher 1 EMT/Paramedics
Incoming emergency calls (total number of calls)	123 604 (314 703)	32 776 (63 025)	28 185 (109 266)
Number of ambulances	45 1 single paramedic manned ambulance, 1 motorcycle unit, 1 intensive care ambulance and 1 anesthesiologist/paramedic manned unit.	31	23 1 nurse anesthetist/paramedic manned unit
Ambulance transports	142 785	47 486	42 000
Dispatcher background	Registered nurses (general, intensive care or anaesthetics nursing)	Registered nurses (general, intensive care or anaesthetics nursing)	Registered nurses (general, intensive care or anaesthetics nursing)
Dispatcher training in general	3 months standard training program initially. One training-day every 12 weeks	Standard training programme initially. One training-day every 6 months. Regular additional courses.	Standard training programme initially. Half a training-day every 12 weeks
Specific training in handling cardiac arrest calls in the dispatch centre.	Initially, less than 1 hour of training on recognition of cardiac arrest and CPR instructions. Yearly review of audio logs, but no special attention to cardiac arrest calls.	Initially 1 day of training dedicated entirely to cardiac arrest. Extended daily focus on cardiac arrest. Instructions to always initiate CPR if in doubt of normal breathing. Long tradition with dispatch-research on cardiac arrest calls	Initially 2 hours of training on recognition of cardiac arrest and CPR instructions. No follow-up training.
Work rotation	EMCC only	EMCC only	50/50 EMCC/ER
Dispatch tool-protocol	The Norwegian Index for Emergency Medical Assistance	The Norwegian Index for Emergency Medical Assistance. (with local cardiac arrest adjustments)	The Norwegian Index for Emergency Medical Assistance

OA-EMCC – Oslo/Akershus Emergency Medical Communication Centre; VT-EMCC – Vestfold/Telemark Emergency Medical Communication Centre; Ø-EMCC – Østfold Emergency Medical Communication Centre; EMT – Emergency Medical Technician; EMCC – Emergency Medical Communication Centre; ER – Emergency Room.

Table 2
Efficacy of recognition of cardiac arrest and pre-arrival CPR instructions.

	OA-EMCC(N = 333)	VT-EMCC(N = 143)	Ø-EMCC (N = 103)	p-value
Adherence to identification algorithm	300 (90)	137 (96)	74 (72)	p < 0.001
- clarification of consciousness	326 (98)	143 (100)	96 (93)	
- clarification of breathing	331 (99)	143 (100)	99 (96)	
- clarification of normal breathing	305 (92)	137 (96)	75 (73)	
Recognition of cardiac arrest	297 (89)	134 (94)	80 (78)	p < 0.001
- immediate recognition	228 (69)	131 (92)	70 (68)	
- delayed recognition	69 (21)	3 (2)	10 (10)	
- cardiac arrest not recognised	36 (11)	9 (6)	23 (22)	
Reasons for lack of recognition				
- misinterpretation of agonal breathing	84 (25)	11 (8)	23 (22)	
- poor adherence to algorithm	13 (4)	0	9 (9)	
- no obvious/other reason	8 (2)	1 (1)	1 (1)	
CPR instructions started	277 (83)	118 (83)	63 (61)	p < 0.001
- chest compressions performed	236 (71)	116 (81)	58 (56)	
- mouth-to-mouth performed	77 (23)	10 (7)	23 (22)	
- CPR stopped due to agonal breathing	12	0	4	

Values given as numbers (percentages). Groups (sites) were compared using Pearsons Chi-square.
OA-EMCC – Oslo/Akershus Emergency Medical Communication Centre; VT-EMCC – Vestfold/Telemark Emergency Medical Communication Centre; Ø-EMCC – Østfold Emergency Medical Communication Centre; CPR = Cardiopulmonary resuscitation.

Table 3
Time intervals for dispatch of ambulance, ambulance response and CPR instructions.

	OA-EMCC(N = 333)	VT-EMCC(N = 143)	Ø-EMCC(N = 103)	p-value
Dispatch of ambulance (min)	0.6 (0.5, 0.7)	0.5 (0.5, 0.6)	0.9 (0.7, 1.0)	<0.001
Time to initial instructions (min)	1.4 (1.2, 1.6)	1.1 (0.9, 1.2)	1.3 (1.2,1.7)	0.002
Time to chest compression instructions (min)	2.6 (2.3, 3.1)	2.4 (2.1, 2.7)	2.2 (1.9, 3.6)	0.55
Time to chest compressions (min)	3.2 (2.9, 3.6)	3.1 (2.6, 3.5)	3.2 (2.4, 4.2)	0.93
Time to ventilation instructions (min)	3.7 (3.2, 4.6)	2.5 (1.4, 4.2)	4.2 (2.7, 6.1)	0.66
Time to ventilations (min)	4.1 (3.5, 4.7)	3.2 (2.3, 4.6)	5.0 (3.7, 6.5)	0.72
Length of call (min)	8.7 (8.0, 9.4)	8.1 (7.4, 8.8)	5.3 (3.4, 7.0)	0.001
Ambulance response interval (min)	8.8 (8.2, 9.2)	7.8 (7.2, 8.6)	8.9 (7.8, 10.7)	0.06

Values given as medians with 95% confidence intervals. Groups were compared using a non-parametric Independent-Samples Kruskal-Wallis Test.
OA-EMCC – Oslo/Akershus Emergency Medical Communication Centre; VT-EMCC – Vestfold/Telemark Emergency Medical Communication Centre; Ø-EMCC – Østfold Emergency Medical Communication Centre.

nition of cardiac arrest. These themes were further divided into 365 unique meaning units sorted into 26 groups. Ultimately, these groups were distilled into three overall themes following the chronological order of a cardiac arrest call. More details from the interviews are presented in Appendix A.

1 Protocol use and platform of knowledge

The use of protocol and whether they considered it a good tool for decision support during cardiac arrest varied widely across the participants. Although they were trained to always follow the protocol, they sometimes deviated from it if they felt their clinical experience would lead them to a different approach and yield a better outcome for the patient.

2 Situational assessment

Collaboration between caller and dispatcher was considered essential for recognition of cardiac arrest. This collaboration was influenced by the emotional state of the caller, and this was described as a very important factor in recognition of cardiac arrest. The caller would convey emotional response through tone of voice, use of certain words and non-verbal cues that indicated the patient was in critical condition, and this would trigger the dispatcher to suspect cardiac arrest even before information about breathing and consciousness was established. This emotional state could also be a barrier to recognition of cardiac arrest.

3 Interrogation strategy/assessment of breathing

Participants found it difficult to assess breathing. "Normal breathing" is not defined in the protocol, and each participant had her/his own definition. They considered it a discretionary interpretation in each situation, and the assessment of normal breathing was for the most part based on their own experience. Caller and dispatcher were described to be "in two different worlds", and it was important for the dispatcher to understand that the caller did not necessarily have the same understanding of "normal breathing".

Discussion

The performance standards varied between our three study sites despite similar organisation, professional backgrounds and dispatch tool/protocols. Criteria based dispatch is less protocol driven compared to more stringent medical priority dispatch systems, and therefore more dependent on individual dispatcher performances. This in-depth study offers new insight that may be used to understand and address factors impacting on how dispatchers handle cardiac arrest calls at both the individual and system level.

Observations at the three EMC centres indicated that the highest performing centre (VT-EMCC) facilitated cardiac arrest recognition by being focused on cardiac arrest in everyday work and being involved in related research projects (Table 1). In-depth interviews with the dispatchers underlined the individual differences in the way they use and understand the same protocols. Observations and in-depth interviews suggested that dispatchers from the highest performing centre were more likely to base their cardiac arrest related decisions on protocol rather than clinical experience and situational assessment, although they also considered these important parts of their decision making. The highest performing centre also had a clear standing order from their medical director to always start CPR when in doubt, and it was common practice to "listen in" on each other's' calls during critical illness or trauma. Dispatchers at the largest centre (OA-EMCC) were the most concerned with over-triage and use of limited resources, and rarely felt they had time or that is was appropriate to "listen in" on other dispatchers calls. These system variations in culture and practices may be of value to medical directors wanting to build a "culture of excellence".

Agonal breathing is a well-known barrier to cardiac arrest recognition,[3,20,34] and our study confirmed this to be a challenge in all of our three participating dispatch centres. By looking specifically at cases with delayed recognition, our results indicate that agonal breathing is an important barrier to high quality dispatch, even when arrest is eventually recognised. Quality assurance programs need to include measures to evaluate and improve cardiac arrest calls were recognition is delayed, not only those that are not recognised. The quality indicators suggested by the AHA in their recent scientific statement[7] does not sufficiently capture data on calls that are suboptimally handled due to delayed recognition.

International guidelines clearly state that if a patient is unresponsive and not breathing normally they should be considered to be in cardiac arrest and treated accordingly.[5,6] This definition of cardiac arrest is widely acknowledged and accepted. By instructing all callers to do CPR when a patient meets these criteria, we accept that some patients may be given CPR even though they are not in cardiac arrest. As medical professionals, dispatchers will understand that our current definition of cardiac arrest is flawed, and if agonal breathing is not clearly described and defined in their cardiac arrest protocols, confidence in the decision support tool/protocol may erode. While lay rescuers need a simple definition, and professional rescuers with inherently integrate additional information (such as signs of circulation, circumstance, etc.), dispatchers operate somewhere in-between. Their medical understanding supersedes their access to independent evaluations.

All unresponsive patients not breathing normally are obviously not in cardiac arrest. In EMCC the occurrence of patients unresponsive due to diabetic shock, stroke, opioid overdose, epilepsy etc. outnumbers cardiac arrests, and these conditions are often obvious to both caller and dispatcher. By not acknowledging the limitations of our current definition and rather enforce strict compliance, agonal breathing will likely continue to plague dispatcher recognition of arrest. Leaving each dispatcher to make their own definition of abnormal breathing is another unlikely solution. Some of our current challenges can be addressed by additional training and monitoring, but we might also have to consider redefining cardiac arrest in the dispatch setting to give the dispatchers new, improved, and more uniform tools to assess breathing. Whether we need a more dynamic description of agonal breathing warrant further studies.

Some important limitations need to be addressed. Auditing audio logs will to a certain extent be open to interpretations. Time intervals may be particularly subjective as it can be difficult to pinpoint the exact time CPR is performed. Problematic cases were discussed amongst at least two researchers until consensus was achieved.

Findings from this study is based on criteria based dispatch and the use of NI as a decision support tool. Our findings may not reflect issues and potentials at other international dispatch centres. Similarly, findings from interviews will apply to the individual informant and will not necessarily be representative for the entire dispatcher population. However, in keeping with the principles of qualitative method of maximum variation, cases believed to be information rich were purposely selected to give a broader understanding of the persisting challenges dispatchers face. Main focus of the study is dispatchers performance standards. Thus, we have not reported patient survival rates nor discussed differences in time intervals of minor clinical relevance. However, it is important to report these time intervals for comparison with other studies and optimal performance standards. Finally, our data collection is from 2013-2014, before the 2015 guidelines with more focus on dispatch centres. Still, our findings suggest that issues challenging dispatchers in 2013-14 continues to challenge dispatchers in 2016. In addition, implementation of changes in guidelines is a complicated process taking years.[35]

Conclusion

Agonal breathing continues to be the main barrier to recognition of cardiac arrest. Our study indicates individual differences among dispatchers' strategies can directly impact on performance, mainly due to the wide definition of cardiac arrest and lack of uniform tools for assessment of breathing. When monitoring key quality indicators, all cardiac arrest calls that challenge the system should be evaluated, also cases with delayed recognition.

Conflict of interest

Olasveengen has received a research grant from the Laerdal Foundation for Acute Medicine.

Sunde has received travel grants and lecture payment from Bard Medical.

Financial support

The study was supported by grants from University of Oslo, South-Eastern Norway Regional Health Authority, Oslo University Hospital, and Laerdal Foundation for Acute Medicine.

Acknowledgements

We would like to thank Trond Thoresen and Mailinn Odden, Vestfold Hospital Trust, for invaluable help in the data collection process and Rune Gerkhen, Oslo University Hospital, for fascilitating the study in Oslo. We also want to thank all dispatchers and EMTs/paramedics in the three study sites for participating in the study, Norwegian National Advisory Unit on Prehospital Emergency Medicine (NAKOS) for providing invaluable infrastructure and the University of Oslo for providing funding for Camilla Hardeland.

Appendix A. Analysis of in-depth interviews

Overview of results

1) Protocol use and platform of knowledge

Subgroups: a) Use and non-use of protocols
b) Education and training

2) Situational assessment

Subgroups: a) Caller – dispatcher collaboration (relationship/cooperation)
b) Circumstances at scene

3) Interrogation strategy/assessment of breathing

Subgroups: a) Assessment of breathing
b) Other indicators of cardiac arrest

Protocol use and platform of knowledge

The use of protocol (NI) and whether they considered it a good tool for decision support during cardiac arrest varied widely across the participants. Although they were trained to always follow the protocol, they sometimes deviated from it if they felt their clinical experience would lead them to a different approach and yield a better outcome for the patient. For example, several participants indicated that the best way to assess normal breathing is broad clinical experience.

> *"To assess the patient I use a hotchpotch of knowledge, experience, protocol, colleagues and intuition".*

> *"Protocol use is not enough to be able to do a good job as a dispatcher. It's ok for support but you have to mix it with experience, and what you have learned out in the field. I would have done a much worse job if I didn't have experience. But then again, you can't use only your experience. You need both"*

> "*When you have worked here a long time you become a bit more. . .. not so dependent on using the protocol. You use more intuition and gut feeling*"

Both experienced and novice dispatchers believed the protocol to be most useful for novice providers. In contrast, most participants expressed concerns about lack of education and training, and some had never had any training on how to recognise cardiac arrest or detect agonal breathing.

They expressed a need for both theoretical education on hypoxia and agonal breathing, as well as more practical, simulation based training. Lastly, the lack of systematic case review was noted, and dispatchers felt there was little feedback unless there was a public complaint. Access to real cardiac arrest calls for training purposes was suggested.

Situational assessment

Collaboration between caller and dispatcher was considered essential for recognition of cardiac arrest. This collaboration was influenced by the emotional state of the caller, and this was described as a very important factor in recognition of cardiac arrest. The caller would convey emotional response through tone of voice, use of certain words and non-verbal cues that indicated the patient was in critical condition, and this would trigger the dispatcher to suspect cardiac arrest even before information about breathing and consciousness was established.

> *"In an emergency call there are incredibly many things you can perceive from the caller. Some times I experience that I just know that it's a cardiac arrest. It's something about the caller, and their tone of voice and how scared they are that triggers something in me"*

This emotional state could also be a barrier to recognition of cardiac arrest. Some callers were calm and first of all expressed concern for irrelevant details, like "*she hasn't eaten very much for a long time now*" or "*he was hospitalised two years ago*". Introductory expressions like these could make the dispatcher believe there was no emergency and in some cases forget to assess consciousness and breathing. Visualization of the scene and circumstances in each particular situation was also considered important for recognition of cardiac arrest, and the dispatcher would integrate all these factors while interrogating callers and assessing their answers.

> *"I think it's important to get a picture of what's going on at scene in my head. Is it a child or is it an adult? Is it at night? Is the patient a sleep in his bed? These are things that influence recognition of cardiac arrest. It all depends on the situation. I think about normal values. Is this normal for this patient in this situation?"*

Interrogation strategy/assessment of breathing

Participants found it difficult to assess breathing. "Normal breathing" is not defined in the protocol, and each participant had its own definition. They considered it a discretionary interpretation in each situation, and the assessment of normal breathing was for the most part based on their own experience. Caller and dispatcher were described to be "in two different worlds", and it was important for the dispatcher to understand that the caller did not necessarily have the same comprehension of "normal breathing". Some had not been taught any strategies for assessing normal breathing and had developed their own interrogation strategy. Some would initially ask if the patient was breathing, some if he was breathing normally. When they were uncertain how to interpret the answer, a variety of different follow-up questions were suggested:

> "*Is he breathing like he normally does? 'Is he breathing like you and me?' "Is he breathing like he is asleep?" "Is the chest rising and falling?" "Can you feel the air from his mouth and nose if you put your hand over them?" "Can you feel warmth in your ear if you put it all the way down to the patients nose and mouth?" "Is he breathing regularly?" " Is he breathing without any noises" "Please count out loud every time he takes a breath." "Pinch the inside of his arm hard to see if the breathing improves*."

Interpretation of answers to these questions also differed. Examples of what was considered normal breathing;

> "*If it is 30 seconds between each breath this is considered abnormal*", "*If the patient is breathing just a little bit, but still regularly and without noises, I consider it normal breathing*".

Several participants argued that there are other questions apart from consciousness and breathing that are relevant to recognition of cardiac arrest. Face/lip/skin colour was often highlighted as the main red flag for recognition of cardiac arrest. Normal skin colour was considered a sign that the patient was not in cardiac arrest, and if it was difficult to assess whether or not the breathing was normal, skin colour was the determining factor for recognition of cardiac arrest.

> *"I have experienced several times that the patient is unconscious and breathing abnormal, and I ask for skin colour, and it's fine, then after some time, they turn blue and I start CPR instructions because it is now a cardiac arrest. I have been wondering if I should have started CPR instructions earlier in those cases"*

> "*If the patient has a bit of a gurgling respiration, or is gasping, I keep the caller on the line to see what happens. It's when he turns blue in the face you realize it's a cardiac arrest*".

Snoring respiration was often considered a distinct sign of a cerebral incident, not cardiac arrest. Some of the participants would

check the medical history, and if the patient had epilepsy, diabetes, chronic obstructive pulmonary disease, history of suicide or a drug addiction, they considered this information important when assessing breathing and used this information to decide whether they should instruct CPR or give other medical advice.

References

1. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513.
2. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377.
3. Berdowski J, Beekhuis F, Zwinderman AH, Tijssen JGP, Koster RW. Importance of the first link: description and recognition of an out-of-hospital cardiac arrest in an emergency call. Circulation 2009;119:2096.
4. Kuisma M, Boyd J, Väyrynen T, Repo J, Nousila-Wiik M, Holmström P. Emergency call processing and survival from out-of-hospital ventricular fibrillation. Resuscitation 2005;67:89–93.
5. Perkins G, Handley A, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.
6. Kleinman EM, Brennan EE, Goldberger DZ, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2015;132:S414–35.
7. Lerner EB, Rea TD, Bobrow BJ, et al. Emergency medical service dispatch cardiopulmonary resuscitation prearrival instructions to improve survival from out-of-hospital cardiac arrest a scientific statement from the American Heart Association. Circulation 2012;125:648–55.
8. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted CPR: time to identify cardiac arrest and deliver chest compression instructions. Circulation 2013;128:1522–30.
9. Ho AFW, Sim ZJ, Shahidah N, et al. Barriers to dispatcher-assisted cardiopulmonary resuscitation in Singapore. Resuscitation 2016;105:149–55.
10. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the Effectiveness of Dispatch-assisted Cardiopulmonary Resuscitation Instructions. Academic Emergency Medicine 2007;14:877–83.
11. Dami F, Heymann E, Pasquier M, Fuchs V, Carron P-N, Hugli O. Time to identify cardiac arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based dispatch system. Disease/Disorder overview 2015;97:27.
12. Clegg GR, Lyon RM, James S, Branigan HP, Bard EG, Egan GJ. 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. Resuscitation 2014;85:49–52.
13. American Heart Association. Adult basic life support. JAMA 1992;268:2184–98.
14. Chamberlain D, Bossaert L, Carli P, et al. Guidelines for advanced life support: A statement by the Advanced Life Support Working Party of the European Resuscitation Council, 1992. Resuscitation 1992;24:111–21.
15. Bossaert L, Handley A, Marsden A, et al. European Resuscitation Council guidelines for the use of automated external defibrillators by EMS providers and first responders: A statement from the Early Defibrillation Task Force, with contributions from the Working Groups on Basic and Advanced Life Support, and approved by the Executive Committee of the European Resuscitation. Resuscitation 1998;37:91–4.
16. Baskett PJF, Bossaert L, Carli P, et al. Guidelines for the basic management of the airway and ventilation during resuscitation: A statement by the Airway and Ventilation Management Working Group of the European Resuscitation Council. Resuscitation 1996;31:187–200.
17. Culley LL, Clark JJ, Eisenberg MS, Larsen MP. Dispatcher-assisted telephone CPR: Common delays and time standards for delivery. Annals of Emergency Medicine 1991;20:362–6.
18. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 8: advanced challenges in resuscitation: section 3: special challenges in ECC. The American Heart Association in collaboration with the International Liaison Committee on Resuscitation. Circulation 2000;102:I229–52.
19. Handley AJ, Monsieurs KG, Bossaert LL. European Resuscitation Council Guidelines 2000 for Adult Basic Life Support: A statement from the Basic Life Support and Automated External Defibrillation Working Group 1 ERC BLS & AED Working Group: Arntz H-R, Bahr J, Baubin M, Bossaert L, Brucan A, Carneiro A, Cassan P, Chamberlain D, Davies S, De Vos R, Ekstrom L, Evans T, Gwinnutt C, Handley A, Lexow K, Marsden A, Monsieurs K, Petit P, Sofianos E, Van Dreuth A, Van Rillaer L, Wik L, Wolcke B. 1 and approved by the Executive Committee of the European Resuscitation Council. Resuscitation 2001;48:199–205.
20. Bobrow BJ, Zuercher M, Ewy GA, et al. Gasping during cardiac arrest in humans is frequent and associated with improved survival. Circulation 2008;118:2550.
21. Fukushima H, Imanishi M, Iwami T, et al. Abnormal breathing of sudden cardiac arrest victims described by laypersons and its association with emergency medical service dispatcher-assisted cardiopulmonary resuscitation instruction. Emergency Medicine Journal 2015;32:314.
22. Bohm K, Rosenqvist M, Hollenberg J, Biber B, Engerström L, Svensson L. Dispatcher-assisted telephone-guided cardiopulmonary resuscitation: an underused lifesaving system. European journal of emergency medicine: official journal of the European Society for Emergency Medicine 2007;14:256.
23. Travers S, Jost D, Gillard Y, et al. Out-of-hospital cardiac arrest phone detection: Those who most need chest compressions are the most difficult to recognize. Resuscitation 2014;85:1720–5.
24. Hardeland C, Olasveengen TM, Lawrence R. Comparison of an advanced medical priority dispatch system (AMPDS) and a criteria based dispatch system (CBD) relating to cardiac arrest calls. Resuscitation 2010;81, 88–88.
25. Den Norske lægeforening. Norsk indeks for medisinsk nødhjelp. Oslo, Den norske lægeforening; Stavanger Åsmund S. Lærdal, 2009.
26. Patton MQ. Qualitative research & evaluation methods. Thousand Oaks,Calif: Sage Publications; 2002.
27. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA 2013;310:2191.
28. Pretzlik U. Observational methods and strategies. Nurse Researcher 1994;2:13–21.
29. Berterö C, Eriksson E, Ek AC. Demanding interaction-given routines: An observational study on leukaemia patients and their nursing staff. International Journal of Nursing Practice 1996;2:201–8.
30. Swanwick M. Observation as a research method. Nurse researcher 1994;2:4–12.
31. Briggs K, Askham J, Norman I, Redfern S. Accomplishing care at home for people with dementia: using observational methodology. Qualitative Health Research 2003;13:268–80.
32. Malterud K. Kvalitative metoder i medisinsk forskning—en innføring, 2 utg. Nordic JournalDiscussion of Nursing Research 2003;23, 50–50.
33. Malterud K. Systematic text condensation: a strategy for qualitative analysis. Scandinavian journal of public health 2012;40:795–805.
34. Eisenberg MS. Incidence and significance of gasping or agonal respirations in cardiac arrest patients. Current Opinion in Critical Care 2006;12:204–6.
35. Berdowski J, Schmohl A, Tijssen JGP, Koster RW. Time needed for a regional emergency medical system to implement resuscitation Guidelines 2005—The Netherlands experience. Resuscitation 2009;80:1336–41.