An Evaluation of Focused Cardiac Ultrasound in Out of Hospital Cardiac Arrest by Advanced Paramedic Practitioners

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ABSTRACT

Objectives

This study describes and evaluates Advanced Paramedic Practitioner (APP) use of Focused Cardiac Ultrasound (FoCUS) in Out of Hospital Cardiac Arrest (OHCA), and relates ultrasound findings with decisions to terminate resuscitation. We report the characteristics of patients who do/do not undergo a FoCUS examination by APPs, ultrasound probe positions utilised and whether FoCUS findings were associated with decisions to terminate resuscitation or to convey patients to an emergency department (ED) with ongoing resuscitation.

Methods

Using data from pre-existing EMS and APP databases, we undertook a retrospective, observational cohort study of all adult medical OHCA patients attended by APPs in the Greater London area during 2018.

Results

Twenty-eight APPs attended 1,444 OHCA patients in 2018 of which 744 underwent FoCUS. The subcostal (SC) window was the probe position most frequently utilised (551/744, 74%) followed by parasternal long axis (141/744, 19%) with significantly smaller representation of the parasternal short axis and apical windows. Absence of Spontaneous Cardiac Motion (SCM) was associated with termination of resuscitation (333/391, 85%) and presence of SCM was associated with conveyance to ED (213/264, 80%). All decisions to terminate resuscitation were within APP scope of practice.

Conclusion

We believe this is the largest prehospital study involving FoCUS in OHCA. We found an association between FoCUS findings and decisions made to either convey patients to hospital or terminate resuscitation. The SC window was the most utilised view and ROLE decisions were deemed to be in accordance with local guidance and practice.

INTRODUCTION

Some UK ambulance trusts have introduced an innovative paramedic role known as Critical Care Paramedics (CCPs) or Advanced Paramedic Practitioners in Critical Care (APPs). APPs are experienced paramedics who undergo additional training including Masters level education, allowing them to gain additional competencies in prehospital critical care (von Vopelius-Feldt and Benger (2014). In the London Ambulance Service (LAS), APPs are targeted to the most seriously ill and injured patients, including out of hospital cardiac arrest (OHCA), with each APP attending on average 1.4 OHCAs per shift. The primary focus of an APP is to ensure high standards in delivery of resuscitation through on scene leadership. APPs also provide enhanced decision making and clinical interventions above that practiced by paramedics. All APPs in the LAS are equipped with portable handheld ultrasound devices (HUD).

Guidance from the Resuscitation Council (UK) (2015) states that when available, focused cardiac ultrasound (FoCUS) may be of benefit in identifying futile resuscitations, citing studies that conclude the absence of spontaneous cardiac motion (SCM) is highly predictive of death, although sensitivity and specificity analyses have not yet been reported. There is currently a paucity of high-quality evidence for FoCUS being incorporated into prehospital guidelines (Quinn and Price, 2017). Moreover, a recent statement on the science from the International Liaison Committee on Resuscitation makes a weak recommendation, based on low level

evidence, against using point of care ultrasound in cardiac arrest (Reynolds et al., 2020).

It is increasingly acknowledged that intra-arrest ultrasound can detract from other essential elements of care, especially high-quality chest compressions (Gardner et al., 2017). Pauses in chest compressions are associated with decreased chances of survival (Deakin and Koster, 2016). Recently the European Society of Cardiology published a position statement on HUDs for FoCUS in which the potential for prehospital use is acknowledged, while outlining limitations in making quantifiable assertions with HUDs (Cardim et al., 2019). Specific training in using these devices and education in image acquisition and interpretation, are also recommended.

The LAS deals with approximately 10,000 OHCAs per year of which active resuscitation is attempted on just over 4,000 patients. At the time of the study, twenty-eight APPs working within the LAS receive one day FoCUS training from an emergency physician, incorporating HUD practice time. This is supplemented by further opportunities to refresh knowledge and practice during monthly training days.

LAS APPs have been using HUDs since May 2014, with the majority of use being in the context of pulseless electrical activity (PEA) OHCA. Local APP guidelines permit termination of a resuscitation in PEA and subsequent recognition of life extinct (ROLE) outside of standard paramedic practice. A key element within this extended ROLE guidance is the absence of organised SCM on FoCUS.

Guidance for termination of adult PEA cardiac arrest

- Adult > 18 years
- Full ALS underway (secured airway & IV/IO access gained)
- No sustained ROSC (>3 min) within the last 30 minutes of PEA
- QRS complexes >0.12msec
- Rate <50 complexes per min or paced rhythm with no mechanical capture
- Patient not known to have renal failure or undergoing dialysis
- No coordinated ventricular wall motion on ultrasound
- No obvious treatable cause identified – H’s & T’s reviewed
- Hypoglycaemia excluded
- Fluid bolus (500mls) given
- Adequate bilateral air entry & good chest rise

- EtCO2 continues to fall to <1.5KPa when chest compressions are stopped
- Absence of two central pulses & absence of heart sounds
- Ensure family are supported & the crews are in agreement
- If in any doubt, contact the APP on call advisor for further advice

This study describes and evaluates APP use of FoCUS in OHCA and relates ultrasound findings with decisions to terminate resuscitation on scene or convey patients to an emergency department (ED). Additionally, the anatomical locations of the HUD probe are related to image findings.

METHODS

Data Collection

Patient characteristics collected were chosen a priori based on those widely reported in published literature on OHCA (Perkins et el., 2015; CARES, 2017; OHCA Project Team, 2018). The LAS maintains an electronic database comprising records of patients attended by APPs. The database was searched to identify all adult medical OHCA patients attended by any APP from 1st January 2018 to 31st December 2018 in order to populate tabled results. Patients obviously deceased on initial ambulance arrival were excluded.

Patients were divided into those conveyed to hospital and those for whom resuscitation was terminated (resulting in ROLE) on scene. All patients were identified as either having FoCUS or not, with reasons ascertained if a ROLE decision was made in the absence of FoCUS. For all those receiving FoCUS, probe positions and reported ultrasound findings were gathered.

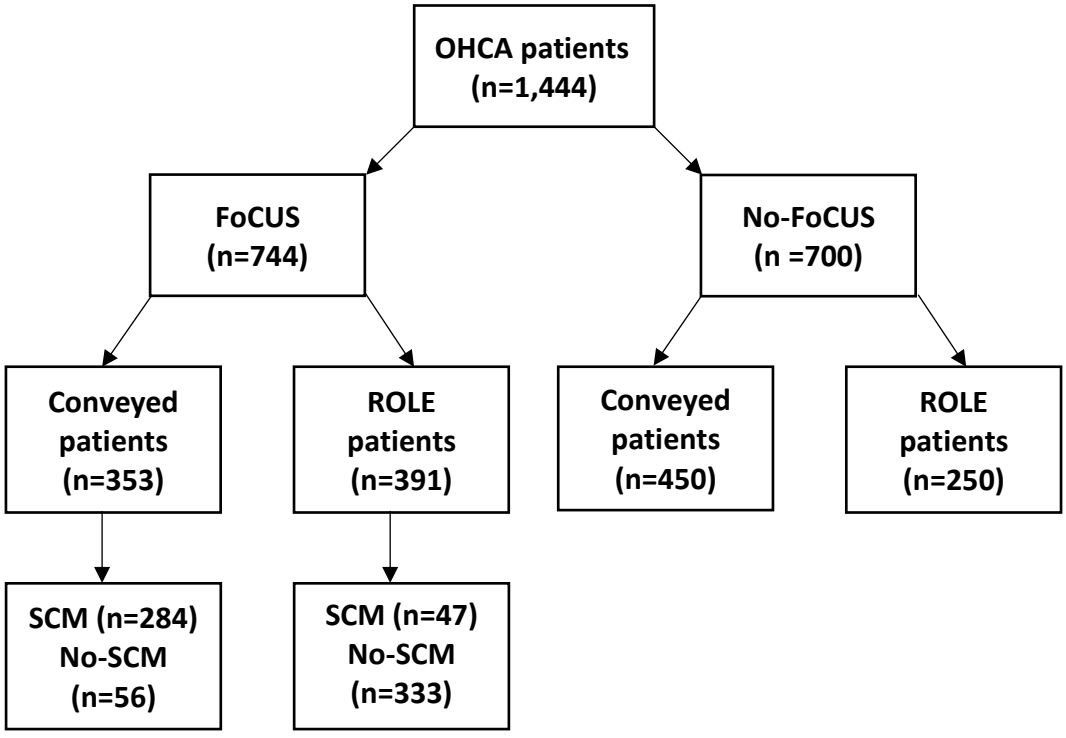
In the database ‘FoCUS findings’ are recorded on a one to five scale by APPs: one = no heart motion; two = agonal uncoordinated movement; three = hypokinetic; four = normal; five = hyperkinetic. To differentiate organised SCM from no-SCM, only scores of one and two were recorded as no-SCM during data analysis. SCM was

assumed in patients who were recorded as three, four or five. This definition is in accordance with the local practice guidance and training.

RESULTS

Of the total number of OHCA emergency calls attended by the LAS for 2018, 1,444 were also attended by an APP. The numbers of patients who underwent FoCUS compared to those who did not was very similar (744/1,444; 51% vs. 700/1,444; 49%) respectively. Patient flow is represented in figure 1. Association was observed between conveyance and the identification of SCM, and ROLE and the absence of SCM. Characteristics of those who did and did not receive FoCUS are shown in Table 1.

Flow Chart 1- Patient journey and association between FoCUS outcome and disposition



OHCA=out of hospital cardiac arrest FoCUS=Focused echocardiography ROLE=recognition of life extinct SCM=spontaneous cardiac motion

Table 1 - Characteristics of 1,444 patients who did and did not undergo FoCUS

		FoCUS	**No FoCUS**
Sex	Male	507 (68.1%)	481 (68.7%)
	Female	237 (31.9%)	219 (31.2%)
Age	Mean (SD)	60.1 (16.78)	56.5 (17.82)
Location	Public Place	233 (31.3%)	282 (40.3%)
	Private Place	511 (68.7%)	418 (59.7%)
Presenting Rhythm	VF/VT	237 (31.8%)	214 (30.6%)
	PEA	239 (32.1%)	170 (24.3%)
	Asystole	266 (35.8%)	279 (40%)
	Not Known/Recorded	2 (<1%)	37 (<1%)
Disposition	ED	353 (47.4%)	450 (64.3%)
	ROLE	391 (52.6%)	250 (35.7%)

FoCUS=focused cardiac ultrasound VF=ventricular fibrillation VT=ventricular tachycardia PEA=pulseless electrical activity ED=emergency department ROLE=recognition of life extinct SD=Standard deviation

Probe Position

Conveyed Patients

Table 2 - Probe position and FoCUS findings in Conveyed patients

CONVEYED	**SC**	**PLAX**	**PSAX**	**Apical**	**Multiple**	**Total**
SCM	213 (80.7%)	53 (84.1%)	4 (100%)	5 (100%)	9 (52.9%	284 (80.4%)
No-SCM	46 (17.4%)	10 (15.9%)	0	0	0	56 (15.9%)

No View	5 (1.9%)	0	0	0	8 (47.1%)	13 (3.7%)

SC=subcostal PLAX=parasternal long axis PSAX=parasternal short axis SCM=spontaneous cardiac motion Multiple=multiple probe positions used

FoCUS was utilised in 353 patients conveyed to hospital (Table 2). The most common finding in this group was SCM (284/353; 80.4%). No-SCM was identified in 56/353 (15.9%) patients. On 13 (3.7%) occasions the APP reported they were not able to ascertain any view.

The view from the SC position was used most frequently (264/353; 74.8%) with 213/264 (80.7%) FoCUS attempts resulting in the identification of SCM. The SC view identified 213/284 (75%) of the SCM in the conveyed group as a whole. Within the SC group, of the remaining 51 patients 46 (17.4%) were found to have no SCM, with 5 (<2%) occasions where no view was achieved.

The parasternal long axis view was the second most frequent probe position utilised, accounting for 63/353 (17.8%) patients. Again, most attempts recorded in this group resulted in SCM being identified (n=53/63; 84.1%) with the remaining having no-SCM (n=10/63; 15.9%). Parasternal short axis and apical views were infrequent (four and five attempts respectively), and all were associated with SCM. Multiple views were recorded on 17 occasions and split between SCM (n=9) and no view (n=8).

<u>ROLE Patients</u>

Table 3 - Probe position and FoCUS findings in ROLE patients

ROLE	SC	PLAX	PSAX	Apical	Multiple	Total
SCM	36 (12.5%)	8 (10.3%)	3 (27.3%)	0	0	47 (12%)
No SCM	244 (85%)	70 (89.7%)	8 (72.7%)	7 (100%)	4 (50%)	333 (85.2%)
No View	7 (2.5%)	0	0	0	4 (50%)	11 (2.8%)

SC=subcostal PLAX=parasternal long axis PSAX=parasternal short axis

SCM=spontaneous cardiac motion Multiple=multiple probe positions used

391/641 ROLE patients had a FoCUS attempt (Table 2). Absence of SCM was found in 333/391 (85.2%) patients. SCM was found to be present in 47/391 (12%) patients, leaving 11/391 (2.8%) patients where the APP reported they were not able to ascertain a view. The absence of SCM was the most common finding for each of the four probe positions utilised.

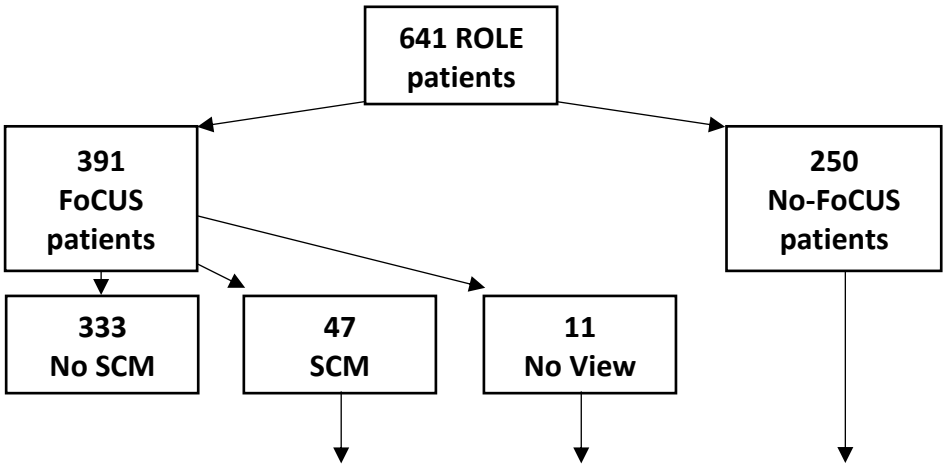
The SC view was used most frequently in 287/391 (73.4%) procedures. Thirty-six of the 47 (77%) cases of SCM were recorded using the SC view. In 7/287 (2.5%) cases, no-view was gained using the SC position.

The parasternal long axis view was used less frequently than the SC view (78 vs 287 cases respectively). Absence of SCM was identified in 70/78 (89.7%) of FoCUS patients, representing 21% of the 333 no-SCM recorded overall. All attempts made via this view resulted in a recordable image. The parasternal short axis and apical views were used infrequently, 3% (n=11) and < 2% (n=7) respectively of all FoCUS attempts made in ROLE patients. SCM was identified by the parasternal short axis view on three occasions and all apical views returned findings of no SCM.

Multiple views were recorded in only 8/391 (2%) patients. This category was used when an APP had utilised more than one view but not specified the most useful view.

Prognostication

Table 4 – ROLE decision rationale



Asystole	13 (27.7%)	4 (36.4%)	186 (74.4%)
Senior Decision	28 (59.6%)	7 (63.6%)	8 (3.2%)
Doctor	-	-	22 (8.8%)
Deceased	-	-	26 (10.4%)
DNACPR	3 (6.4%)	-	5 (2%)
Agonal	2 (4.2%)	-	-
Records Incomplete	1 (2.1%)	-	3 (1.2%)

ROLE=recognition of life extinct FoCUS=focused echocardiography SCM=spontaneous cardiac motion DNACPR=do not attempt CPR

Table 4 shows that of 641 patients who underwent ROLE, 250 (39%) did not have FoCUS performed. 247 (98.8%) of these patients are recorded as having a valid documented reason for a ROLE decision. The most common reason was asystole,

recorded in 186 (74.4%) patients. Late identification of signs unequivocally associated with death occurred in 26 (10.4%) patients. These occasions involved an APP arriving to support EMS crews who had already started resuscitation. For 22 (8.8%) patients a doctor was on scene and made a ROLE decision. A senior on-call clinician (Consultant Paramedic/Doctor) was consulted by telephone in 8 (3.2%) of the 250 cases and approved a ROLE decision. Late identification of a valid DNACPR (Do Not Attempt CPR) was the documented reason in five patients. In three cases records were incomplete.

For patients who underwent ROLE after a FoCUS attempt, 333/391 (85%) had no SCM, and the decision was accordant with guidelines. However, 47/391 (12%) of patients had SCM reported. Of these, 28/47 (59.6%) patients with SCM underwent ROLE following consultation with the on-call senior clinician. Thirteen patients (27.7%) subsequently became asystolic after a FoCUS attempt allowing ROLE within standard guidance. In a further two cases, the APP had recorded ‘agonal’ heart activity, allowing for a ROLE due to no organised SCM. In three cases a DNACPR became apparent after resuscitation had begun. In one case records were not complete.

No view accounted for 11 (2.8%) patients of the 391 for whom a FoCUS attempt was made prior to ROLE. Seven of these were referred to the senior on-call clinician and four subsequently became asystole.

DISCUSSION

The majority of patients presented in a private setting and were male, which is consistent with previous reports describing large UK OHCA populations (OHCA Project Team, 2018; Perkins et al., 2018). However, the APP OHCA patient cohort is younger (mean of 58.4 years of age) than described in those populations (mean of 63.5 years of age). As recognised in the literature, this may reflect the selective criteria employed to target critical care resources to patients thought to have a higher likelihood of survival (von Vopelius-Feldt and Benger, 2014). Increasing age has been associated with poorer outcomes (OHCA Project Team, 2018).

Due to the dearth of literature describing patient characteristics of prehospital FoCUS it is not possible to make meaningful comparisons. In our series, 10% more patients underwent FoCUS in private settings compared with a public location. FoCUS was primarily used in the context of ROLE and it is possible that more patients were conveyed to hospital from a public place due to the challenges of leaving deceased patients in more communal settings. Additionally, bystander CPR may be more frequent when OHCA occurs in a public rather than in a private location, generating more ROSC patients and conveyances. Survival from public OHCA has been reported as higher (OHCA Project Team, 2018).

Compared to LAS data for 2017/2018 (London Ambulance Service, 2018), an APP is more likely to attend a patient who is in a shockable rhythm than most paramedics (31% vs. 20.3%). This finding has an implication for increased survivability and therefore conveyance to ED. Again, this difference might be due to preferential APP dispatch to witnessed OHCA.

FoCUS was performed most often in the PEA group in our study. In a meta-analysis by Gaspari et al. (2016), a similar proportion of patients presenting with PEA underwent FoCUS, 225/414 (54%), with 38/327 (12%) presenting asystole. This contrasts with a meta-analysis by Tsou et al. (2017) who reported that asystole accounted for most FoCUS (n=819; 48%), followed by PEA (n=591; 35%) and then the shockable rhythm group (n=196; 12%).

SC is the view used most frequently by APPs, accounting for 74%. The SC view is most easily accessible during cardiac arrests (Breitkreutz, 2018). Probe positions used for the parasternal long and short axis views inevitably interfere with chest compressions. Although images can be gained during chest compression pauses, the safe, effective and timely resumption of compressions may be hampered by use of ultrasound gel applied to the chest. Furthermore, when mechanical CPR is performed using the LUCAS-2^{TM} device used by APPs, this may form a physical barrier to the anterior chest wall. The apical view requires placing the patient in a left lateral position to optimise images (Sloan, 2018) and is not practical during resuscitation.

Parasternal long axis was the preferred view in 19% of patients, with parasternal short axis and apical views infrequently used (3.6%). Given the nature of the dataset we were unable to explore the rationale for decisions to use one probe position over another or why a view may have been gained with one probe position but not another. Other than occasions where no view resulted from a SC view, the appeal of the parasternal long axis may be that it provides more anatomical detail over the parasternal short axis views. Parasternal short axis is predominantly concerned with imaging left ventricular contractility (Sloan, 2018). It is also worth considering that FoCUS may not always have been undertaken during active chest compressions, allowing for easier access to the anterior chest wall. Local guidance allows APPs to select their own choice of probe position.

No image was obtained in 24/744 (3.2%) patients. This is less than that reported by other studies exploring paramedic use of ultrasound (Reed et al., 2017; Rooney et al., 2016; Heegaard et al., 2010).

SCM was reported in the majority of conveyed patients, while absence of SCM was reported in the majority of the ROLE group (85%). However, 16% of patients with no SCM were still transported to hospital. Gaspari et al. (2016) reported that three patients in their cohort survived to hospital discharge having had no SCM. Decision making in OHCA is multi-factorial and decisions to convey may also involve patient location, family wishes, reversible causes and ease of extrication, thus APPs are not solely making ROLE decisions based on the absence of SCM.

Despite the strategy of targeting APPs to OHCAs deemed more viable, ROLE decisions made by APPs (44.3%) was fractionally higher to that for the ambulance service as a whole (43.8%), perhaps indicating that APPs enact ROLE in situations where standard paramedic practice does not permit. It is plausible that without APP involvement many futile resuscitation attempts might continue and result in unnecessary transportation of patients to hospital ED under emergency conditions. This might have implications for an otherwise dignified death at home, as well as practical considerations around extrication whilst maintaining high-quality CPR.

Increased risk to EMS personnel and other road users during emergency journeys has also been recognised (Grundgeiger et al., 2014).

LIMITATIONS

Limitations are conspicuous by the retrospective, observational nature of the study. All findings are descriptive, highlighting associations but not causation. Chronology is not explored and we do not report survival data. Additionally, reporting bias is conceivable due to the primary authors status as an APP and investigator within the EMS system concerned. All image findings were reported and not subject to expert review.

CONCLUSION

We believe this is the largest prehospital study involving FoCUS in OHCA. In this cohort we found association between patients undergoing ROLE with FoCUS findings of no SCM, and association between FoCUS findings of SCM with patients being conveyed to hospital. The SC window was the most utilised view and ROLE decisions were deemed to be accordant with local guidance and practice. We recommend further prospective study of prehospital FoCUS involving the independent verification of recorded of images.

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