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Clinical paper

# Platelet dysfunction after out of hospital cardiac arrest. Results from POHCAR: A prospective observational, cohort study

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## Abstract

**Aim:** Coagulation and platelet function following out of hospital cardiac arrest (OHCA) at admission to a UK cardiology centre were investigated prospectively in this observational feasibility study, and compared to that of patients receiving percutaneous coronary intervention (PCI) for ST segment elevation myocardial infarction (STEMI).

**Method:** Blood samples taken immediately at emergency department admission from patients after OHCA of probable cardiac origin were analysed using near-patient thromboelastometry and a platelet function analyser. Physiological parameters, demographic information, bleeding rates and 30-day survival were recorded, and compared to that of patients undergoing PCI for STEMI.

**Results:** Thirty patients were enrolled into each group. Platelet activation with thrombin receptor stimulation was reduced in OHCA patients compared to STEMI patients; mean TRAP AUC OHCA 79.3 (95% CI 63.7–94.9) vs STEMI 101.6 (95% CI 87.4–115.8), $p = 0.03$. The maximum clot firmness time was prolonged in the OHCA group compared to the STEMI group; 1718s (1545s–1906s) vs 1544s (1387s–1709s), $p = 0.01$. Other measures of clot formation and strength were comparable between groups. Hyperfibrinolysis (maximum lysis $>= 15\%$) was common in both groups (57% in STEMI; 50% in OHCA) but did not increase 30-day bleeding risk.

**Conclusion:** OHCA patients demonstrated reduced thrombin receptor function at hospital admission but overall clot formation dynamics comparable to STEMI patients, indicating no gross coagulopathy post OHCA in our cohort. Hyperfibrinolysis was common both post OHCA and after STEMI. The results of this small feasibility study cannot draw clinical conclusions but will inform power calculations for future studies.

**Keywords:** Cardiac arrest, Platelets, Coagulation, Fibrinolysis, Bleeding

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## Introduction

Approximately 30,000 people receive cardiopulmonary resuscitation (CPR) in the United Kingdom (UK) every year following out of hospital cardiac arrest (OHCA).[1] For those who have return of spontaneous circulation (ROSC), treating the underlying cause of cardiac arrest is central to their initial management. A common cause of cardiac arrest is acute coronary artery occlusion, most effectively treated with timely percutaneous coronary intervention (PCI).[2,3]

PCI consists of blood flow restoration and stent deployment, requiring judicious pharmacological platelet inhibition to prevent further thrombus formation within the stent. In this aspect post-OHCA care closely follows that for patients presenting with ST-segment elevation myocardial infarction (STEMI). In the conscious patient, oral loading with antiplatelet therapy is the strategy of choice, although even in this group there is a delay to effective platelet inhibition.[4] OHCA patients are invariably unconscious so require a nasogastric tube for administration of crushed or dispersed drugs (which can be time consuming, may delay PCI and has an unknown pharmacological profile) or rectal administration. Alternatively, intravenous glycoprotein IIb/IIIa or P2Y12 inhibitors may be used, which are novel drugs largely untested in the OHCA population.[5] At present, it is not clear whether post-OHCA platelet inhibition with the same drug strategy as is offered post STEMI is optimum.[2]

The complication of acute stent thrombosis is reportedly more common following OHCA than STEMI (10% and 2% respectively).[6,7] It is not clear why this is the case but delays in drug administration due to logistical challenges discussed above, altered drug metabolism and/or inherent abnormalities of clotting and platelet function may be implicated. The risk of stent thrombosis must be balanced against excess bleeding rates, reported in up to 56% of Intensive Care Unit (ICU) admissions following cardiac arrest.[8] Bleeding has been postulated to occur as a result of therapeutic cooling, unpredictable antiplatelet drug pharmacokinetics, and multiorgan failure in the days following cardiac arrest.

Both stent thrombosis and bleeding complications can lead to excess morbidity and mortality. At present, we have little evidence upon which to balance the risks of bleeding and clotting in OHCA patients. As a first step, it would be valuable to understand what abnormalities of coagulation occur in the OHCA population prior to any drug administration.

Cardiac arrest is the end point of a wide range of physiological insults, and so to pinpoint patients likely to have experienced OHCA as a result of coronary occlusion, an international consensus defined the "Utstein comparator" group.[9] Utstein comparator patients have a witnessed OHCA likely due to a cardiac cause, and are in an initial arrest rhythm amenable to defibrillation. By recruiting this group, we aimed to identify a more homogenous population who are most likely to benefit from PCI. Patients undergoing PCI for STEMI offer the most comparable group to the Utstein comparator as they too have an acute coronary thrombus, without the systemic effects of cardiac arrest.

We undertook a pilot observational cohort study to investigate whether a coagulopathy of cardiac arrest is apparent in Utstein comparator patients at admission to a single UK tertiary cardiology centre following OHCA.

## Methods

The study was approved by the Wales REC 7 regional research ethics committee (16/WA/0161) and registered with ISRCTN (ISRCTN34122839). The study protocol has been published.[10]

### *Study population*

Cardiac arrest group: Adult patients admitted at any time of day following OHCA who had sustained ROSC but remained comatose, met Utstein comparator criteria, and were deemed suitable for admission to ICU were eligible. The inclusion criteria were witnessed arrest; probable cardiac cause; initial arrest rhythm amenable to defibrillation. The exclusion criteria were non-cardiac cause for arrest apparent.

Comparator group: Any adult brought to the cardiac catheter laboratory (CCL) with an acute STEMI for which they were offered PCI as primary treatment was eligible for recruitment.

Patients known to be; pregnant, detained by Her Majesty's Prison Service or under the Mental Capacity act, or lacking capacity prior to admission were not enrolled.

### *Consent and ethical considerations*

Due to the nature of the disease under investigation, OHCA patients deemed eligible were automatically enrolled into the study and a retrospective opinion was sought from a consultee. A personal consultee was a close family member, whilst a professional consultee (approached only if a personal consultee could not be identified) was the patient's lead healthcare professional so long as they were not connected with the study. The consultee was asked to sign an assent form stating that they believed the patient would agree to continued enrolment. Patients were approached for retrospective consent once recovered and deemed to have regained capacity.

The comparator group gave verbal assent prior to undergoing emergency PCI and subsequently signed a consent form within 48 h of enrolment.

### *Study design*

This observational cohort feasibility study was undertaken at a single regional cardiology centre that covers a population of approximately 1 million in the South West of England, offering 24-h PCI, supported by a 21 bedded general ICU.

OHCA patients were admitted to the emergency department, assessed, stabilised and underwent clinical interventions (such as tracheal intubation, line insertions, computed tomography (CT) imaging, bedside echocardiogram) before being transferred to the CCL. Sedation with an infusion of Propofol, ventilation on an anaesthetic machine (Ohmeda Datex, Drager) and PCI were undertaken according to local practice. STEMI patients were admitted directly into the CCL from the emergency medical services. The cardiology team assessed the patient, and gained consented for PCI treatment if deemed necessary.

In both instances the clinical team were at liberty to deliver any drugs, including anticoagulant and antiplatelet drugs, and adjuncts they felt appropriate. Immediately following study enrolment two citrated blood samples were taken, alongside routine admission tests. OHCA patients' samples were taken from peripheral venous puncture or a freshly placed arterial line shortly after admission to the emergency department, before administration of anti-platelet drugs or anti-coagulation, and prior to commencement of formal temperature management. STEMI patients' blood was drawn from the PCI arterial access sheath prior to administration of systemic anti-coagulation. All STEMI patient had received aspirin by the time of arrival in the CCL.

The ROTEM® delta analyser (Tem international, Munich) is a near-patient rotational thromboelastographic system for global assessment of coagulation function that enables direct measurement of the kinetics of clot formation, clot viscoelastic strength, clot lysis and the fibrinogen and components of clot formation. The test utilises three different activating reagents to assess the tissue factor (EXTEM reagent), or contact (INTEM reagent) mediated activation of coagulation. The fibrinogen component of clot formation is assessed using the FIBTEM reagent, which includes an inhibitor of platelet function. To assess platelet function, we employed the ROTEM® platelet system (Tem international, Munich), in which platelets are stimulated with activators of either the platelet thrombin receptor (TRAP reagent) or P2Y12 ADP receptor (ADP reagent) and functional responses are measured by an electrical impedance endpoint.

The ROTEM® viscoelastometry test generates several parameters:

Clotting Time (CT) indicates time in seconds from start of measurement until a clot with an amplitude of 2 mm forms, reflecting the time taken for soluble coagulation factors to initiate thrombin generation.

Clot Formation Time (CFT) is the time taken for a 2 mm clot to develop into a 20 mm one and reflects clot propagation which requires both platelets and coagulation factors.

Maximum Clot Firmness (MCF) is the maximum amplitude of clot formed in millimetres. It represents the quality of the clot formed, reflecting contributions from both fibrinogen and platelets (EXTEM reagent) or fibrinogen alone (FIBTEM reagent).

Maximum Lysis (ML) is the percentage of the clot lysed by the end of the reaction time expressed as a percentage of MCF and reflects fibrinolysis.

MCF time and Lysis Onset Time report the time taken from the start of measurement to reach MCF and a 20% reduction in MCF respectively.

The ROTEM® platelet generates three parameters for each activating reagent:

Maximum speed (MS) is the maximum slope of the impedance versus time curve, reflecting rate of platelet aggregation.

Amplitude at 6 min (A6) measures change in electrical impedance after six minutes exposure to the activating agonist.

Area Under the Curve (AUC) describes the area under the curve from the start of measurement to 6 min, reflecting overall platelet activation.

Research staff were on call 24 h a day during the study window to process samples. Samples were processed within 120 min of being drawn. All samples were analysed with the ROTEM® temperature set at 37 °C. Each ROTEM® test was run for 120 min.

### Data collection

The following data were collected; symptom onset time, emergency service arrival time; arrival time in hospital; admission blood results; drug treatments given prior to and in the CCL; demographic data; past medical and drug histories. Patients were followed up for 30 days for bleeding, return to CCL, and survival.

### Outcome measures and data analysis

The primary aim of this study was to document platelet function in the OHCA patient population prior to administration of antiplatelet drugs. The secondary outcome was to document the coagulation function in this population.

Conflicting data exists as to what coagulation and platelet derangement may be expected post OHCA,[11–16] and therefore no a priori power calculation was undertaken. This study was intended to provide preliminary data to power future definitive studies.

Prior to data analysis the ROTEM® and platelet traces were manually reviewed. Those with non-standard shaped traces were arbitrated by the authors (AS and AM). Results with evident artefact were manually analysed where possible, otherwise they were removed from the final dataset. In total 1 platelet ADP and 2 INTEM traces were discarded.

Data were analysed using STATA (version 14.2, StataCorp, Texas). Where data was missing only the available numbers were analysed, no assumptions were made about missing data. Shapiro–Wilk tests for normality were carried out. Parametric tests were used to analyse relationships between means and $Chi^2$ or Fisher's exact tests for categorical data depending on sample size. Mann–Whitney u tests were carried out on non-parametric data, and median difference was calculated using the Hodges–Lehmann Estimate. Logistic regression was used for binary outcomes. Significance was set at alpha = 0.05. Unless otherwise stated, all ROTEM® results refer to EXTEM reagent results. Reference ranges reported are those published by the ROTEM® manufacturer.[17]

## Results

Thirty patients were recruited into each study arm between September 2016 and May 2017 (Fig. 1). Three OHCA patients were excluded from analysis; 2 due to lack of consent, 1 due to insufficient blood samples. One patient had data for platelet but not viscoelastometry parameters due to insufficient blood samples.

The groups were well matched for age, gender and time parameters (Table 1). OHCA patients had a lower body temperature at the time of blood sampling; 35.2 °C (34.7–35.8) vs 36.5 °C (36.4–36.7). OHCA patients were more often taking antiplatelet or anticoagulant medications pre-admission, more were hypertensive but fewer were smokers. Twenty-six of 28OHCA patients received bystander CPR. Median time from collapse to sustained circulation was 22.5 min (range 4–63 min).

### Platelet parameters

The mean admission platelet count of OHCA patients was $256 \times 10^9$/L. No STEMI patient had a full blood count prior to PCI. The mean platelet count at the end of PCI was $235 \times 10^9$/L in OHCA patients and $251 \times 10^9$/L in STEMI patients.

Platelet function tests (Table 2) demonstrate that mean TRAP AUC was lower in the OHCA arm (79.3, 95% CI 63.7–94.9) compared to the STEMI arm (101.6, 95% CI 87.4–115.8) p = 0.03. Similarly, the A6 TRAP results were lower in the OHCA arm (18.0, 95% CI 14.4–21.6) than the STEMI arm (23.2, 95% CI 19.9–26.5), p = 0.03.

The platelet functional responses with the ADP reagent were similar in the two groups (Table 2).

The differences in TRAP response remained even when only P2Y12-antagonist naive patients were compared (OHCA TRAP AUC 75.0 (95% CI 59.9–90.2) versus STEMI TRAP AUC 101.6 (95% CI 87.4–115.8); mean difference of 26.5 (95% CI 6.2–46.8); p = 0.01).

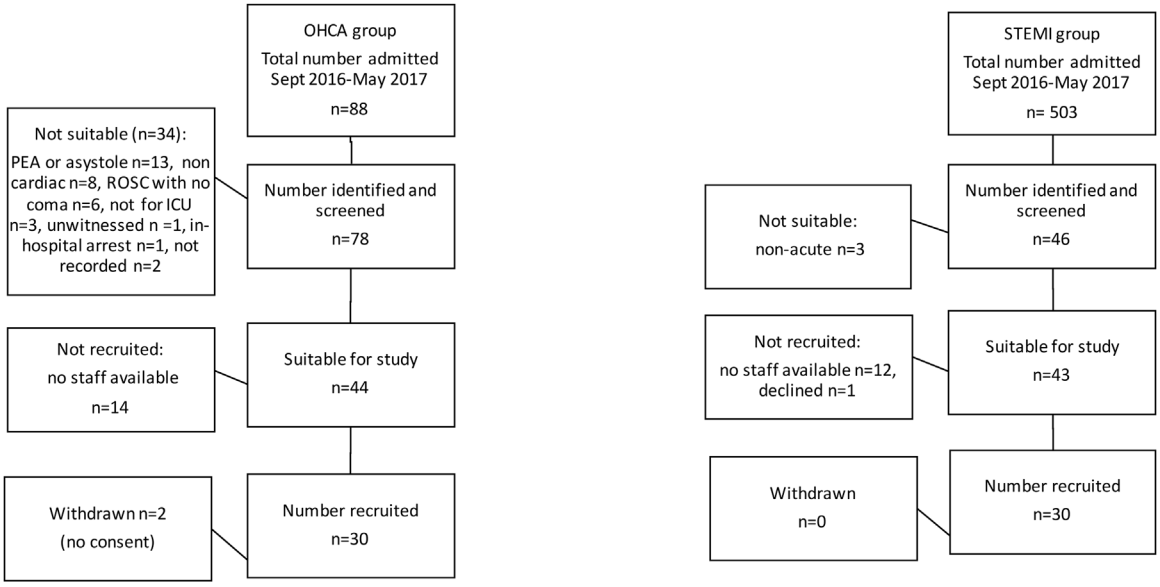


**Fig. 1 – Recruitment flow diagram.**

### *Coagulation parameters*

The absolute values of thromboelastometry are displayed in Table 3, 6 and 7. A proportion of patients in both groups exhibited an EXTEM MCF above the reference range for healthy controls; 7/26 (27%) of OHCA patients, 7/29 (24%) of STEMI patients. No patients demonstrated an MCF below the lower limit, indicating adequate clot formation in both groups and no gross coagulopathy.

The MCF time was prolonged in the OHCA patients at 1718s (95% CI 1545–1906) as compared to STEMI patients 1544s (95% CI 1387s – 1709s), p = 0.01, suggesting that OHCA patients take significantly longer to reach maximal clot size (Table 3, Supplementary Data file Fig. S11, S12).

**Table 1 – Patient characteristics.**

| | OHCA (n = 28) | STEMI (n = 30) |
|---|---|---|
| Sex male: female (% Male) | 20:8 (71%) | 22:8 (73%) |
| Age | 67.5 | 65.0 |
| (median, years) (interquartile range) | (55–76.5) | (54–75) |
| Body temperature at time of blood sample | 35.2 °C[a] | 36.5 °C |
| (average °C, 95% confidence interval) | (34.7–35.8) | (36.4–36.7) |
| Symptom onset to arrival in coronary catheter lab time | 02:43 | 02:40 |
| (median, hours) (interquartile range) | (02:03–03:53) | (01:50–04:55) |
| Time from emergency call to hospital arrival | 02:04 | 01:47 |
| (median, hours) (interquartile range) | (01:04–04:29) | (01:19–02:49) |
| Hospital arrival to coronary catheter lab time | 00:56 | 0[b] |
| (median, hours) (interquartile range) | (0:33–01:13) | |
| Time from symptom onset to antiplatelet loading | 03:40 | 01:25 |
| (median, hours) (interquartile range) | (02:02–07:12) | (00:50–04:07) |
| Heparin administered in coronary catheter lab (n, %) | 16 (57) | 29 (97) |
| Use of intravenous P2Y12 inhibitor Cangrelor® in coronary catheter lab (n, %) | 15 (54) | 1 (3) |
| Use of glycoprotein IIb/IIIa inhibitor in coronary catheter lab (n, %) | 4 (14) | 4 (13) |
| Received primary PCI (n, %) | 18 (64) | 26 (87) |
| Hypertension (n,( %)) | 17(61) | 7 (23) |
| Smoker (n,( %)) | 3 (11) | 8(27) |
| Diabetes mellitus(n,( %)) | 6 (20) | 6 (21) |
| Ischaemic heart disease (n,( %)) | 3 (11) | 2 (7) |
| Previous myocardial infarction(n,( %)) | 4 (14) | 3 (10) |
| Pre-admission aspirin use(n,( %)) | 7 (25) | 2 (7) |
| Pre-admission anticoagulant use (n,( %)) | 6 (21) | 3 (10) |

[a] Data only available for 18 patients.
[b] All patients arrived straight in CCL.

**Table 2 – Platelet function parameters, comparing all STEMI and OHCA patients.**

| ROTEM assay | Parameter (ROTEM® reference range) | OHCA (n = 27) Mean (95% confidence interval) | STEMI (n = 30) Mean (95% confidence interval) | P value for mean difference | P value for mean difference |
|---|---|---|---|---|---|
| TRAP | AUC (6–56) | 79.3 (63.7–94.9) | 101.6 (87.4–115.8) | 22.3 (1.7–42.8) | 0.03 |
| | MS (5–14) | 8 (6.4–9.6) | 9.9 (8.6–11.2) | 1.9 (−0.1 to 3.9) | 0.07 |
| | A6 (15–36) | 18.0 (14.4–21.6) | 23.2 (19.9–26.5) | 5.2 (0.5–9.9) | 0.03 |
| ADP | AUC (38–113) | 51.6 (38.8–64.4) | 58.5 (49.9–67.1) | 6.87 (−7.9 to 21.7) | 0.35 |
| | MS (3–10) | 4.3 (3.2–5.3) | 4.5 (3.8–5.3) | 0.3 (−0.9 to 1.5) | 0.65 |
| | A6 (11–29) | 13.7 (10.4–17.1) | 15.9 (13.8–18.1) | 2.2 (−1.7 to 6.0) | 0.26 |

AUC = area under the curve. MS = maximum speed. A6 = amplitude at 6 min.

**Table 3 – Median ROTEM® EXTEM coagulation parameters, comparing STEMI and OHCA patients.**

| Parameter (ROTEM® reference range) | OHCA group (n = 26) Median (interquartile range) | STEMI group (n = 30) Median (interquartile range) | Median difference and 95% confidence interval (Hodges Lehmann Estimate) | P value (Mann Whitney u) |
|---|---|---|---|---|
| Clotting time (s) (38–79) | 68 (62–78) | 64.5 (61–69) | 4 (0–9) | 0.06 |
| Clot formation time (s) (35–159) | 76.5 (51–90) | 62 (56–79) | 4 (−5 to 19) | 0.39 |
| Maximum clot firmness (mm) (50–72) | 66 (63–74) | 68 (66–71) | −1 (−5 to 2) | 0.39 |
| Maximum clot firmness time (s) | 1718 (1545–1906) | 1544 (1387–1709) | 184.5 (39–339) | 0.01 |
| Maximum lysis after MCF (%) (≤15%) | 14.5 (10–16) | 15 (11–19) | −1 (−5, 1) | 0.36 |
| Lysis onset time (s) | 6187 (4510–6796) | 5034 (4228- 5464) | 825.5 (−759 to 2065) | 0.32 |

There were no statistically significant differences between the groups in other viscoelastometry parameters (Table 3, Supplementary Data file tables S1, S2). Aside from the MCF time, no other parameter exhibited clot formation dynamics outside of the reference ranges, indicating no hypercoagulability or severe coagulopathy in either group.

### *Fibrinolysis*

Maximum lysis equal to or above 15% by the end of the 2-h ROTEM® analysis, indicating hyperfibrinolysis, was demonstrated in 13/26 (50%) OHCA patients and 17/30 (57%) STEMI patients. Within the OHCA group, patients with hyperfibrinolysis had shorter MCF times compared to OHCA patients without hyperfibrinolysis; 1595s (1469–1739) vs 1906s (1665–2147), $p < 0.01$.

There were no differences in the other viscoelastometry parameters between OHCA patients with hyperfibrinolysis and those without (Table 4). One OHCA subject exhibited intermediate hyperfibrinolysis (complete clot lysis after 34 min) and another late onset lysis (complete clot lysis after 108 min).[18]

### *30-day outcomes*

In the OHCA group, 30-day survival was 15/28 (54%). The absolute 30-day bleeding rate was 11/28 (39%) compared to 3/30 (10%) in STEMI patients, giving an odds ratio of bleeding of 5.8 (95% CI 1.4–23.9, $p = 0.02$). No coagulation differences were demonstrated between those OHCA patients who bled and those who did not, or between those who died and were alive at day 30 (Supplementary Data file Tables S3,S4).

Rates of stent thrombosis are difficult to quantify accurately in observational studies. Of the 5 cardiogenic deaths in the OHCA arm, 1 was classified as a probable stent thrombosis by ARC criteria, giving a crude stent thrombosis incidence of 3.6% (1/28).[19,20]

## Discussion

In this feasibility study we have successfully recruited OHCA patients at emergency department admission for studies of coagulation and compared it to that of patients undergoing primary PCI for STEMI. These groups were similar at baseline despite their different routes of clinical presentation. Assessment of platelet function after OHCA with the novel ROTEM® platelet system showed reduced responsiveness to activation of thrombin receptors, as compared to STEMI patients. ADP receptor activity was comparable between the two patient populations, which goes against the findings of other groups.[13,16] Despite reduced thrombin receptor activity, maximum clot firmness was the same in both groups.

Maximum clot firmness time was significantly prolonged in OHCA patients, corroborating the tendency of delayed clotting post OHCA.[14] However, OHCA patients did eventually produce clots of the same firmness as STEMI patients indicating that no gross coagulopathy appears to exist, in contrast to some previous studies,[11] but supporting others.[21] The clotting time and clot formation time results show a trend to being prolonged, as had been demonstrated by other authors, suggesting this part of the coagulation pathway may be most sensitive to peri-arrest changes.[12]

**Table 4 – ROTEM® coagulation and platelet parameters comparing OHCA patients with hyperfibrinolysis (maximum lysis > = 15%) against those with no hyperfibrinolysis.**

| Parameter (ROTEM® reference range) | Hyperfibrinolysis (n = 13) median (interquartile range) | No hyperfibrinolysis (n = 13) median (interquartile range) | Median difference and 95% confidence interval (Hodges Lehmann Estimate) | P value |
|---|---|---|---|---|
| Clotting time (s) (38–79) | 67 (62–71) | 68 (67–103) | −5 (−30 to 3) | 0.10 |
| Clot formation time (s) (35–159) | 79 (73–87) | 54 (50 - 91) | 14 (−13 to 30) | 0.49 |
| Maximum clot firmness (mm) (50–72) | 64 ( 64–68) | 71 (61–74) | −4 ( −10 to 4) | 0.30 |
| Maximum clot firmness time (s) | 1595 (1469–1739) | 1906 (1665–2147) | −352 (−606 to −113) | <0.01 |
| TRAP AUC | 74 ( 60–114) | 83 (43–101) | 11 (−27 to 49) | 0.46 |
| ADP AUC | 53 (33–85) | 36 ( 19–62) | 15 ( −15 to 41) | 0.41 |
| Time from collapse to sustained ROSC (mins) | 20 (9–34) | 23 (20–25) | −5 (−15 to 11) | 0.41 |
| Incidence of bleeding by day 30 (n) | 5/13 | 5/13 | | – |
| Hospital mortality (n) | 4/13 | 8/13 | | 0.12 |

Our rates of hyperfibrinolysis post OHCA are similar to other authors.[12] However, we found lower rates of fulminant, intermediate and late hyperfibrinolysis and no incidence of severe coagulopathy. OHCA patients exhibiting hyperfibrinolysis (ML ≥ 15%) had coagulation parameters comparable to the OHCA group as a whole (Table 4), in keeping with the findings of Schochl.[12] Our cohort's prolonged MCF time has not been previously reported.

These findings suggest that OHCA patients tend towards slower clot formation, and some patients are also slower to lyse clots once they are formed (demonstrated by the wide interquartile range in lysis onset times in the OHCA group) (Table 3). This heterogeneity may explain why some OHCA patients are more prone to bleeding and others to clotting complications. To further assess whether this is the case, measurement of fibrin degradation products, thrombin and activated protein C or thrombomodulin will be helpful.[11]

Acute Traumatic Coagulopathy (ATC) has been more thoroughly investigated and we were interested to understand whether a similar process is occurring post OHCA. ATC is postulated to occur as a result of increased anticoagulant activity in the face of preserved procoagulant function, with increased fibrinolysis.[22] Our data suggests that some patients show a similar picture; with hyperfibrinolysis and preserved MCF. We did not demonstrate definitive increased anticoagulant activity. The pattern of increased fibrinolysis and preserved clot formation was demonstrated in both the STEMI and OHCA cohorts, and therefore does not seem unique to cardiac arrest. Instead it may be a physiological response to a systemic insult and global hypoperfusion.

Given the pragmatic design of this feasibility study there are a number of limitations. Although the difference in body temperatures between groups is not a confounder for analysis (as all samples were prewarmed and processed at 37 °C) it may nevertheless have implications for clinical management. Our sample size is small and we did not set out to show an effect on clinical outcomes.

Due to the small sample size we have not undertaken multi-regression analyses of potential confounders. Limited staff availability meant that we were unable to recruit a consecutive sample. The grading of bleeding was not blinded. Body temperature on admission was collected retrospectively and was not available for all OHCA patients. Clinical management was left to the discretion of clinicians, and variations may have influenced our results.

This study was intended to provide proof-of-concept data to quantify the magnitude and direction of differences in coagulation and platelet function parameters between the two study populations. Given our small sample size, we were not expecting any differences to reach statistical significance. Nevertheless, we are confident that we now have an accurate representation of coagulation and platelet function on admission following a witnessed cardiac arrest in the Utstein comparator patient group. Future work will need to focus on elucidating the mechanism behind the altered platelet and fibrin system functions and correlating these to clinically meaningful outcomes.

## Conclusion

We have demonstrated that Utstein comparator OHCA patients exhibited reduced thrombin receptor activated platelet function when compared to STEMI patients.

ROTEM® coagulation analysis revealed admission clot formation dynamics tended towards prolonged clotting times post OHCA but with an ultimately normal, or increased, maximum clot firmness achieved. Over half of patients in both groups demonstrated hyperfibrinolysis.

The small sample and hypothesis-generating nature of this work preclude any clinically relevant conclusions being drawn but provides data to inform power calculations for future studies.

## Conflicts of interest

None of the authors have relevant conflicts of interest to declare.

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All procedures performed involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.01.025.

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