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CASE REPORTS

# Rotational thromboelastometry (ROTEM®)-guided diagnosis and management of amniotic fluid embolism

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**ABSTRACT**
Amniotic fluid embolism is a rare but often catastrophic emergency. The non-specific clinical features and lack of diagnostic tests make it a diagnosis of exclusion. Point-of-care visco-elastometric testing is being increasingly used during obstetric haemorrhage. We present a case of amniotic fluid embolism, diagnosed and managed using rotational thromboelastography. During a precipitous labour, a 21-year-old multiparous woman became pale, distressed and disorientated. The fetus was delivered using forceps. Simultaneously maternal cardiac arrest occurred and advanced life support was commenced. As there was no obvious bleeding, pulmonary embolism was considered the most likely diagnosis and preparation was made to thrombolyse. During resuscitation, rotational thromboelastometry demonstrated haemostatic failure, supporting a diagnosis of amniotic fluid embolism. This reversed the decision to thrombolyse and focused the team on resuscitation and management of coagulopathy. Targeted blood products were given using a local protocol specific to obstetric bleeding. Return of cardiac output was achieved. The total measured blood loss was more than 3.6 L and transfusion was guided by point-of-care tests. Transfused blood products were six units of packed red blood cells, one pool of platelets, 12 units of fresh frozen plasma and 14 g of fibrinogen concentrate. This case demonstrates amniotic fluid embolism with haemostatic failure, without initial revealed blood loss. The high mortality of amniotic fluid embolism necessitates rapid diagnosis and aggressive management. Laboratory tests in this context are impractical in informing clinical decisions, showing the value of point-of-care testing in facilitating team work and timely administration of targeted blood products.


***Keywords***: Embolism; Amniotic fluid; Point-of-care testing; Rotational thromboelastometry; Cardiac arrest

## Introduction

Maternal cardiac arrest is a rare but catastrophic obstetric emergency. In the United Kingdom (UK) thromboembolism represents the commonest cause of direct mortality during and up to six weeks postpartum (1.13/100 000 maternities).[1] This is followed by haemorrhage, suicide, sepsis and amniotic fluid embolism (AFE) (incidence 0.35/100 000 maternities).[1] Amniotic fluid embolism is usually associated with early and profound disseminated intravascular coagulation (DIC) and coagulopathy,[2,3] often leading to significant postpartum haemorrhage. The associated rapidly changing coagulation profile means that laboratory testing is impractical in informing real-time clinical decision making.[3] In contrast, pulmonary embolism is only rarely associated with coagulopathy. Since AFE has no specific diagnostic clinical features or laboratory tests, it remains a diagnosis of exclusion.[4]

Point-of-care visco-elastometric testing, such as rotational thromboelastometry (ROTEM®), is being increasingly used in obstetrics.[5–7] In our region, an ongoing quality improvement programme, the Obstetric Bleeding Strategy for Wales (OBSCymru), has introduced ROTEM® devices into all obstetric led delivery units in Wales, supported by an all-Wales obstetric bleeding protocol for blood and blood product use.[8] We present a case of AFE diagnosed on the basis of acute, profound coagulopathy observed and then managed using serial ROTEM® tests.

## Case report

A healthy 21-year-old gravida 2 para 1 (previous spontaneous vaginal delivery) woman was admitted to the labour ward, following induction of labour with

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prostaglandin because of mild pre-eclampsia. On arrival, her blood pressure (BP) was 145/80 mmHg, heart rate (HR) 85 beats per min (bpm), and oxygen saturation ($SpO_2$) in room air 96%. She had no intravenous (IV) access, as per local guidance.

Labour was precipitous and during the second stage, 18 minutes after arriving on the labour ward, a deep deceleration was noted on the cardiotocograph. The obstetric and anaesthetic registrars on-call attended the delivery room with a senior midwife. On vaginal examination the fetus was in the occipito-anterior position at +2 station and an assisted vaginal delivery was planned. Concurrently, the patient became pale and disorientated (HR 132 bpm, $SpO_2$ 91% on room air). She was placed in the left lateral position, facemask oxygen applied and 16-gauge IV access secured. After a failed attempted suction-assisted vaginal delivery, she became increasingly restless. The emerging fetus was delivered by Wrigley's forceps. Intramuscular syntocinon was given for active third stage management. Simultaneously, the patient became unresponsive, was repositioned supine and cardiac arrest confirmed by the anaesthetist. Cardiopulmonary resuscitation was commenced, and the defibrillator electrocardiogram showed pulseless electrical activity. A cardiac arrest call was initiated and the medical team arrived shortly afterwards.

Advanced life support (ALS) continued following the UK Resuscitation Council adult algorithm.[9] Apparent blood loss was minimal, but continuous gravimetric measurement was initiated as standard postpartum care. Advanced life support continued, with IV adrenaline boluses of 1 mg being given immediately and on alternate rhythm checks. The patient was intubated and endotracheal placement confirmed using portable end-tidal capnography. Volume-controlled ventilation was initiated using a portable transfer ventilator (Oxylog 3000; Drager, Germany) and adequate oxygenation maintained with mean airway pressures of 17 $cmH_2O$. Faced with a young healthy patient in sudden cardiovascular collapse and profound cyanosis in the absence of bleeding, the most likely diagnosis was considered to be massive pulmonary embolism.[4] Echocardiography was requested, however with no on-site cardiologist at night, this was not feasible. Given the working diagnosis, alteplase thrombolysis was requested, however alteplase is not stocked in the labour ward, so procurement was delayed.

After 18 minutes of ALS, the first return-of-spontaneous-circulation occurred. At this time abnormal vaginal bleeding was apparent. This prompted activation of the major haemorrhage protocol and IV administration of 1 g of tranexamic acid. Repeat cardiac arrest occurred and at a measured but ongoing blood loss of 900 mL, two units of packed red blood cells were transfused. Difficulty obtaining further IV access necessitated placement of intraosseous access, with a single successful attempt into the left tibia.

Twenty minutes after initial cardiac arrest, abnormal bleeding from venepuncture sites raised the suspicion of abnormal coagulation, and the anaesthetic registrar requested that, in addition to laboratory bloods and blood gas samples, a point-of-care ROTEM® be performed using the device located on labour ward. This showed complete haemostatic failure with an unrecordable FIBTEM A5 and EXTEM clotting time (CT) (Fig. 1, Table 1), consistent with a severe consumptive coagulopathy. This coagulopathy was more typical of AFE than pulmonary embolism and contraindicated the use of an antifibrinolytic agent. Thus thrombolysis was not started, and management focused on ALS and coagulopathy therapies. Six grams of fibrinogen concentrate, four units of fresh frozen plasma (FFP) and a pool of platelets were immediately requested according to the OBSCymru protocol.[8] Corresponding laboratory results later revealed a prothrombin time (PT) >80 s, an activated partial thromboplastin time (APTT) >125 s and unrecordable serum (s.) fibrinogen, confirming severe DIC. A ROTEM® repeated after administration of these products showed a persistent unrecordable FIBTEM A5 and EXTEM CT. A further 4 g of fibrinogen

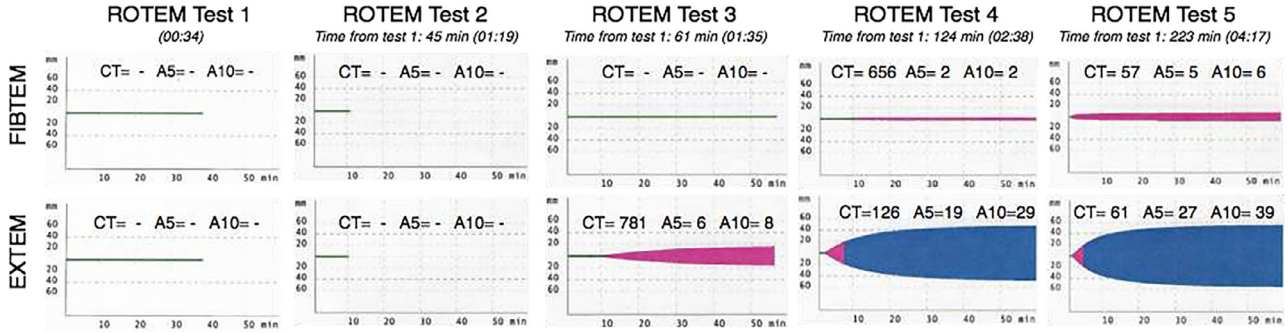


**Fig. 1** Point-of-care ROTEM® tests performed during resuscitation. Tests 1 and 2 during cardiac arrest: Test 3 on arrival in the operating theatre; Tests 4 and 5 in the operating theatre. Normal values are FIBTEM A5 ≥12 mm and EXTEM clotting time (CT) <75 s[8]

**Table 1 Point-of-care ROTEM® tests performed during resuscitation. Normal values are FIBTEM A5 ≥12 mm and EXTEM clotting time (CT) <75 s[8]**

| | ROTEM Test 1 (00.34) | ROTEM Test 2 (time from test 1 45 min) | ROTEM Test 3 (time from test 1 61 min) | ROTEM Test 4 (time from test 1 124 min) | ROTEM Test 5 (time from test 1 223 min) |
|---|---|---|---|---|---|
| FIBTEM A5 (mm) | – | – | – | 2 | 5 |
| EXTEM Clotting Time (s) | – | – | 781 | 126 | 61 |

concentrate and two units of FFP were infused. An arterial blood gas analysis at an inspired oxygen fraction ($FiO_2$) of 100% showed a temperature corrected pH of 6.99, $pO_2$ 11.4 kPa, $pCO_2$ 5.1 kPa, s. bicarbonate 9.2 mmol/L, and s. lactate 11.3 mmol/L.

Cardiopulmonary resuscitation continued through three further short episodes of return-of-spontaneous-circulation (each less than four minutes), supported by an adrenaline infusion plus adrenaline boluses given on alternate ALS cycles; and treatment of hypocalcaemia and hyperkalaemia. Pulseless electrical activity rhythms persisted throughout episodes of cardiac arrest. The uterus was well contracted throughout.

After 70 minutes, following the fifth and final return-of-spontaneous-circulation, she was transferred to the operating theatre for examination, suturing and continued management of haemorrhage. Another ROTEM® performed on arrival showed an unrecordable FIBTEM A5 and EXTEM CT of 781 s (Fig. 1, Table 1). Although still grossly abnormal, this represented the first demonstrable coagulation activity. Further blood products were requested[8] (4 g fibrinogen concentrate, four units FFP, two units packed red blood cells). Measured blood loss[10] was 2400 mL and haemorrhage control was supported by suturing a first degree tear. To maintain uterine tone an oxytocin infusion, 15-methyl prostaglandin F2α (Carboprost) and misoprostol were given.[8] Ergometrine was avoided due to the history of pre-eclampsia.

Further surgical intervention was deferred pending correction of the coagulopathy. Two further ROTEM® tests demonstrated continued improvement of parameters (Fig. 1, Table 1) and clinically, bleeding stopped. Before transfer to the intensive care unit, a final ROTEM® showed a FIBTEM A5 5 mm and EXTEM CT 61 s. Corresponding laboratory results were PT 14.9 s, APTT 49.2 s, and s. fibrinogen 1.2 g/L. In total, six units of red blood cells, one pool of platelets, 12 units of FFP and 14 g of fibrinogen concentrate were administered. Total measured blood loss by continuous gravimetric and direct measurement was greater than 3600 mL.

Overnight, the patient remained haemodynamically stable. A plasma sample demonstrated a raised zinc coproporphyrin, which while not diagnostic, has been shown to be elevated in AFE.[11] She was extubated on day two, and made a slow recovery, with neurological deficits affecting motor function, vision and higher brain function. She was transferred to an acute stroke unit, referred to neuro-rehabilitation and subsequently discharged home. At a three-month follow-up she demonstrated improved mobility but with a stiff gait; improving left-sided motor power, an ongoing visual disturbance and an abnormal affect. Her male infant was discharged from the special care baby unit after 12 days, suffering from hypoxic-ischaemic encephalopathy (grade 2), but is developing normally to date.

## Discussion

Amniotic fluid embolism is a rare obstetric emergency with high mortality; maternal and neonatal survivors often suffer significant morbidity.[12] Diagnosis is often made post-mortem or after exclusion of other causes, based on non-specific findings. Rapid diagnosis and aggressive management of haemodynamic collapse, coagulopathy and systemic complications may contribute to improved outcomes.

In a previously healthy patient, AFE must be differentiated from other causes of cardiovascular collapse such as thromboembolism.[1] In this case, features supportive of a diagnosis of AFE included a precipitous labour, reversible hypoxaemia and profound early coagulopathy, observed on ROTEM®. Although a consumptive coagulopathy in association with cardiac arrest secondary to pulmonary embolism has been reported in non-obstetric populations,[13] in the 113 cases described none had absent fibrinogen or unrecordable PT/APTT values, as described here. The rapid and severe coagulopathy described, initially observed on point-of-care testing and confirmed with laboratory studies, was disproportionate to that associated with pulmonary embolism and cardiac arrest and is more characteristic of AFE.[14]

If an echocardiograph had been rapidly available, this might have aided forming a diagnosis.[15] However the appearances in acute massive pulmonary embolism and AFE could be expected to be similar; both demonstrating an enlarged hypokinetic right ventricle, tricuspid regurgitation and pulmonary hypertension.[16,17]

The pathology underlying the coagulopathy associated with AFE, whether a consumptive coagulopathy or massive fibrinolysis, remains controversial.[18,19] This

uncertainty makes point-of-care whole blood coagulation testing particularly valuable: it facilitates rapid identification of deficiencies in fibrinogen, platelets and coagulation factors on a timescale that is useful in informing diagnosis, initial and subsequent management, by means of repeated testing.

Although cases utilising point-of-care coagulation testing during management of AFE have been reported,[20,21] neither describe sudden cardiac arrest or profound haemostatic failure, as demonstrated in this case. Collins et al. reported a case during caesarean section in which ROTEM® was used,[21] demonstrating haemostatic incompetence (an initial FIBTEM A10 of 5 mm) and hyperfibrinolysis. This was not seen in our patient. Our case presented a prolonged period of complete haemostatic failure that was resistant to large doses of blood products.

An additional important learning point demonstrated by this case is reflected by how point-of-care testing can impact on multidisciplinary team dynamics. In our unit, ROTEM® testing is routinely performed for rapid assessment of obstetric bleeding. In most cases, coagulation parameters remain normal, focusing the team on other obstetric interventions.[2] In this case, the profoundly abnormal ROTEM® results facilitated rapid liaison between the anaesthetic and haematology teams who were supporting the administration of patient-targeted blood products.

Our use of point-of-care whole blood coagulation testing resulted in a significant, timely and potentially life-saving shift in clinical management, by providing diagnostically useful information in real-time. It also prevented inappropriate thrombolysis administration which could have had a further deleterious effect. Finally, ROTEM® aided the assessment of progress during the resuscitation and directed blood product decisions, through a protocol-based approach to obstetric bleeding.

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