The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study.

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The CAPS study

Objective

To describe the incidence, risks, management and outcomes of cardiac arrest in pregnancy in the UK population, with specific focus on the use of perimortem caesarean section.

Design

A prospective, descriptive study using the UK Obstetric Surveillance System (UKOSS).

Setting

All UK hospitals with maternity units

26 **Population**

27 All women who received basic life support (BLS) in pregnancy in the UK between
28 1 July 2011 and 30 June 2014 (n=66)

29 **Methods**

30 Prospective case identification through UKOSS monthly mailing.

31 **Main Outcome measures**

32 Cardiac arrest in pregnancy, perimortem caesarean section, maternal death.

33 **Results**

34 There were 66 cardiac arrests in pregnancy, resulting in an incidence of 2.78 per
35 100 000 maternities (1:36000 95% CI 2.2-3.6). 28 women died (case fatality
36 rate 42%). 16 women arrested solely as a consequence of obstetric anaesthesia,
37 12 of whom were obese. Basic and advanced life support were rapidly delivered.
38 Those who died were more likely to have collapsed at home. Perimortem
39 caesarean section (PMCS) was performed in 49 women, 11 in the emergency
40 department. The time from collapse to PMCS was significantly shorter in women
41 who survived (median interval 3 versus 12 minutes, p=0.001). 46 of 58 babies
42 were born alive; 32 babies to surviving mothers and 14 to women who died.

43

44 **Conclusion**

45 Cardiac arrest is rare in the pregnant UK population, however, nearly a quarter
46 of cases are precipitated by obstetric anaesthesia, suggesting an opportunity to
47 reduce the incidence further. Maternal survival rates of 58% were achieved with
48 timely resuscitation, including PMCS, delay in which was associated with
49 maternal death. Inpatient arrests were associated with higher survival rates
50 than arrests that occurred outside the hospital setting.

51

52 **Keywords**

53 Cardiac arrest, perimortem caesarean section, resuscitation, maternal morbidity,
54 maternal mortality

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56 **Tweetable abstract**

57 25% of cardiac arrest in pregnancy is caused by anaesthesia. Rapid perimortem
58 section improves survival.

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64 **Introduction**

65 Estimates suggest that cardiac arrest in pregnancy occurs in around 1 in 30000
66 pregnancies¹. However, there has been no recent assessment of this rate despite
67 the increasing age and morbidity of the antenatal population in the United
68 Kingdom (UK). The UK Confidential Enquiry into Maternal Deaths report for the
69 2003-5 triennium noted 52 women who had undergone perimortem caesarean
70 section (PMCS)². The outcome for the mother in these cases was clearly fatal,
71 since they were identified from within the population of women who died. The
72 number of women managed with PMCS had doubled since the previous report. A
73 retrospective study³ in The Netherlands, assessing 15 years of data up to 2008,
74 also described an increase in the use of PMCS in maternal cardiac arrest, citing
75 the introduction of the Managing Obstetric Emergencies & Trauma (MOET)
76 course as partly responsible for this shift in practice. PMCS was performed later
77 than the optimal five minutes⁴ and outcomes were poor.

78 Perimortem caesarean section is now taught on the MOET and similar courses
79 across Europe⁵. The importance of rapid delivery after cardiac arrest for
80 maternal benefit is becoming a widely accepted practice. The rationale for
81 performing PMCS within 5 minutes of arrest is that this will minimise the risk of
82 maternal neurological damage from cerebral anoxia⁵. Irreversible anoxic brain
83 injury occurs more quickly in pregnant than non-pregnant women.⁵ Emptying
84 the uterus in maternal cardiac arrest can result in rapid improvement, with
85 return of spontaneous circulation⁶. There may also be a chance of neonatal
86 survival. It is perceived that there is still significant delay in the decision making
87 to perform a PMCS³. There may be several factors affecting this delay, for

instance lack of senior presence at the time, awaiting speciality input in an emergency department, reluctance to perform the procedure in a non-sterile environment, fear of medico legal implications and the erroneous belief that PMCS is performed exclusively for fetal benefit. There are no prospective data, however, to assess the timing with which this intervention is performed in practice and the relation to outcomes.

The aim of this study was to use the UK Obstetric Surveillance System (UKOSS), to identify cases of cardiac arrest in pregnancy, and details of associated perimortem caesarean sections in the UK over a three year period in order to estimate the incidence of cardiac arrest in the UK obstetric population, describe how cardiac arrest in pregnancy is managed and report maternal and fetal outcome data. This enabled comparisons to be made with current retrospective series⁷.

Methods

Using the UK Obstetric Surveillance System (UKOSS), we conducted a national, prospective descriptive study. The UKOSS system is designed to study rare and severe complications of pregnancy and childbirth in the UK and is now well established, having commenced data collection in 2005. The UKOSS methodology has been described elsewhere⁸. Each obstetrician-led maternity unit in the UK has nominated clinicians who are responsible for completing a monthly return to UKOSS. This return notifies UKOSS of any cases which are under surveillance at that time. Women with severe maternal morbidity are transferred to an obstetrician-led unit if they have previously been cared for at home or in a midwifery-led unit and thus will be captured within UKOSS even if

their initial morbid event occurred in a midwifery-led setting. Awareness of UKOSS and its current list of conditions under surveillance is very high amongst obstetricians, obstetric anaesthetists and midwives.

The definition of cardiac arrest is the cessation of cardiac function; however, the Resuscitation Council (UK) guidelines of 2010 consider that the identification of a pulse is not necessary before the commencement of basic life support (BLS)⁹. An unresponsive patient with abnormal breathing requires immediate BLS, i.e. chest compressions and, if possible, ventilation breaths. The National Cardiac Arrest Audit of the Resuscitation Council (UK) and the Intensive Care National Audit and Research Centre gathers data on ‘all individuals receiving chest compressions and/or defibrillation’. We defined cardiac arrest as any woman who had received BLS during pregnancy. Between 1 July 2011 and 30 June 2014, clinicians were asked to report all cases where BLS had taken place in a pregnant woman. In the final year of data collection (July 2013 to June 2014), we expanded our criteria to include women who received BLS in the immediate post-partum period (up to 24 hours postpartum), following our observation that many women did not meet the case definition because cardiac arrest had occurred immediately after delivery. We felt that collecting information on this group of women, many of whom would have been deteriorating prior to delivery, was highly relevant to our study aims. The change in criteria was clearly stated on the UKOSS notification card.

Clinicians were sent a data collection form (available at <https://www.npeu.ox.ac.uk/ukoss/dcf>), following a case notification. Using the maternal and baby notes, a series of questions were answered on the circumstances of the arrest, predisposing factors, the management of the arrest

and the outcome for mother and child. The data collected were anonymous. If completed forms were not returned, up to five reminders were sent. Cases were checked, on receipt of the data collection form, to ensure that they met the case definition. Duplication of reports was avoided by cross-checking the woman's year of birth and estimated date of delivery.

Incidence was estimated using the denominator maternity figures from the Office for National Statistics, National Records Scotland and The Northern Ireland Statistics and Research Agency for the three years of the study. Data were tested for distribution and tested for between group differences, using appropriate parametric and non-parametric tests as indicated. Categorical data were compared using contingency tables with Chi Square and Fisher's Exact values quoted appropriately. Logistic regression was used to examine associations between potential sociodemographic and obstetric predictors and survival after cardiac arrest. Variables with a p-value <0.2 in the unadjusted analysis were entered in a multivariable model. Analyses were conducted using SPSS version 22 software (IBM SPSS Statistics) with the exception of logistic regression which was conducted using STATA version 13 software (StataCorp, College Station, TX, USA).

Results

Incidence and characteristics

During the three year surveillance period, 125 cases were reported to UKOSS in an estimated 2,347,670 maternities. Of these, 66 cases met the case definition, which had to include cardiac compressions following maternal collapse. The incidence of maternal cardiac arrest was, therefore, 2.8 per 100 000 maternities

(95% CI 2.2-3.6). In the final year of the surveillance period, 25 additional cases were identified in women who had cardiac arrests in the immediate postnatal period together with 23 women who had antenatal arrests in an estimated 759,092 maternities. Thus, the estimated incidence, for that final year, of maternal cardiac arrest during pregnancy or immediately postpartum is 6.3 per 100 000 maternities (95% CI 4.7-8.4).

Twenty-eight women died, representing a case fatality rate of 42% (95% confidence interval, CI, 30-55%). Table 1 shows the characteristics of those who survived and those who died. Only maternal BMI of 30kg/m² or more was significantly associated with survival after multivariable analysis.

Most women, n=51 (77%), were not in labour when they arrested. Of those in labour, n=15, more women survived than died, n=13 and 2, respectively (p=0.02). Of the 66 women, 27 were identified as having co-morbidities, some multiple, which may have contributed to maternal arrest. The most common problems reported were: asthma n=8, mental health problems n=3, cardiac disease n=2, hypertension n=2, haematological n=2, autoimmune n=2 and endocrine problems n=2. There were no significant differences in co-morbidities between survivors and women who died. Eight of 66 women had pregnancy-induced hypertension or pre-eclampsia, however, this was not associated with mortality; four women (50%) survived and 4 (50%) died. Gestational diabetes, n=6, was the second most frequent pregnancy related complication. There was no association with maternal outcome; four women survived and two died.

Cardiac arrest details

Cardiac arrest occurred in a number of locations, with a significant association between place of collapse and maternal survival on unadjusted analysis (figure

1). We considered the impact on maternal outcome of the key areas taught on resuscitation courses individually, namely basic life support (BLS), advanced life support (ALS) and perimortem caesarean section (PMCS). The provision of BLS and ALS was prompt and similar in those women who survived and those who died. The time from diagnosis of cardiac arrest to commencement of resuscitation was recorded as it is impossible to determine the exact time of arrest. Time to performance of PMCS was significantly shorter in the women who survived (table 2), noting, however, that this was clearly related to the location in which the arrest occurred; women who died were more likely to have collapsed at home.

Cardiac output was restored in a total of 48 women, 38 of whom ultimately survived their cardiac arrest. Hence, the survival rate following cardiac arrest was 58%. The time from collapse to delivery in the survivors group was 7 (IQR 2.5-17.5) minutes compared with 16 (IQR 6.5-43.5) minutes in the group where the women died ($p=0.04$). For all groups, resuscitation was provided for a median of 24.5 minutes (range 0-164). Time to restoration of cardiac output was 6 minutes (IQR 4-21) in the survivor group compared with 50 minutes (IQR 32-57) in the women who died $p<0.01$.

Many of these differences are likely to be explained by the differences in the locations in which women initially collapsed.

In 29 of the women the method by which aortocaval compression was relieved was recorded; in the majority of cases (21) by tilting of the pelvis. Manual displacement of the uterus as the method of moving the gravid uterus was used in only four women.

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213 **PMCS details**

214 Forty-nine women had a PMCS performed, of which 11 were performed in the
215 emergency department. Seventeen women did not have a PMCS performed for
216 the following reasons: cardiac output restored n= 6, gestation below 20 weeks
217 n= 6, gestation not considered to be interfering with cardiopulmonary
218 resuscitation n=1, Gestation unknown n= 1, No equipment available n=1 and
219 woman died at home n= 1. Only 2/28 (7%) women who died did not have an
220 appropriate PMCS that should have had one, one of these women had already
221 died at home.

222 Twenty-two women (45%) were moved from the place of collapse for the
223 following reasons: transfer from home to hospital n=11, cardiac output restored
224 n=4, need for equipment n=2, theatre already prepared at time of collapse n=2,
225 already en route to theatre n=1, for better surgical access n=1 or because of a
226 need for theatre staff n=1. Of the 25 women not moved for their PMCS 18/25
227 (72%) survived, whereas of those who were moved 8/22 (36%) survived.

228 Survival appeared significantly more likely when the woman was not moved
229 from the site of collapse (figure 2) and when PMCS was performed promptly
230 (table 2). However, allowing for those women who were transferred for a
231 medical indication, either from home to the ED or because of returning cardiac
232 output requiring general anaesthesia, only seven women had avoidable moves,
233 of whom three (43%) died. This figure was not statistically significant from the
234 number who survived such a move (p=1.0 Fisher's Exact Test).

235 The decision to perform a PMCS was taken predominantly by obstetricians and
236 was performed by senior obstetricians in the majority of cases. There were

some attempts made at aseptic precautions, although data were not complete.

In 12 cases no precautions were taken (table 3). The majority of PMCS were performed within the recommended five minutes from unresponsive maternal collapse (table 3).

Causes of collapse

Data were available for 59 women regarding the suspected cause of maternal arrest, Table 4. In 19 women, the cause identified at post mortem was also recorded. In the women who survived, n=38 (58%), information about a presumed cause for maternal collapse was recorded for 37 women. Of the 28 women who died, data was provided ascribing a cause of death in 21 (75%).. Sixteen women had cardiac arrest as a direct complication of obstetric anaesthesia. One additional woman was reported as having two events, both capable of causing a cardiac arrest. These anaesthetic causes were: problem with intubation n=3, cardiovascularcollapse following epidural top-up n=3, total spinal anaesthetic (from *de novo* intra-theal block) n=10 and anaesthetic other n=1. All these women survived. Note that 12 of the 16 women who had a cardiac arrest solely due to obstetric anaesthesia were obese, and this may explain the apparent association between maternal obesity and survival. Of the postnatal arrests reported in the final year, n=26, the most common reasons for collapse were: hypovolaemia n=11, amniotic fluid embolism n=5 and thromboembolic events n=3. The longest delivery to arrest interval was 12 hours and 25 minutes, with 16 of the postnatal arrests occurring within an hour of delivery. In total, seven of the 26 women died.

Maternal care post collapse

Of the 38 women who survived, 16 (42%) had additional maternal morbidity. Whilst some had more than one cause of morbidity, of the primary morbidities reported, six had neurological complications, five had postpartum haemorrhage, two had coagulopathy, two had renal complications and one had cardiac morbidity. Forty-five women were admitted to an intensive care unit (ICU) following their collapse, 12 subsequently died. Five women who survived were not admitted to intensive care following their collapse; these were all in the group where collapse was secondary to an anaesthetic cause. The median ICU stay was 3.5 days, range 1-71. Five women were admitted to a coronary care unit, some after initial care on an ICU, with a median stay of 5 days, range 4-12. The maternal median days in hospital was eight [range 3-147]. Data on maternal morbidity or mortality was not collected after inpatient discharge.

Fetal outcome

Data were available for 58 babies, of whom 46 were born alive; 32 babies to surviving mothers and 14 to women who died. Seven of the mothers of the 12 stillborn babies also died. Data were available for 35 of the 49 cases regarding the time of PMCS and survival. Twenty-four of 25 babies survived (96%) when PMCS was performed within five minutes compared with seven of ten babies (70%) when PMCS occurred over five minutes after cardiac arrest ($p=0.059$), noting the association between location of maternal collapse and delay in PMCS. Birth weights ranged from 1766-2744 grams in the babies of mothers who died compared to 2489-3329 grams in the babies of women who died, reflecting a

more advanced gestational age (table 1). When the mother died, the median 5 minute Apgar score was 3 (range 2-5) and cord arterial pH was 6.61 (range 6.33-6.8). These results were statistically significantly worse than when the mother survived, when the median Apgar score was 7 (range 6-8, $p=0.01$) and arterial pH was 7.05 (range 6.96-7.26, $p=0.001$). The median stay on NICU was 13 days (range 3-101) for babies of mothers who died compared with four days (range 1-108) in babies of mothers who survived ($p=0.09$). Some surviving babies had neurological and respiratory complications, in both maternal groups, but the numbers of affected babies reported were too small to make any further comment. In total, seven babies had neurological complications, six had respiratory complications and two had sepsis. We did not collect data following discharge from the neonatal unit. Five babies, born alive, were subsequently recorded as dying in the early postnatal period.

Discussion

Main findings

We estimate an incidence of 2.8 cardiac arrests in pregnancy per 100 000 maternities (1:36 000), and 6.3 arrests in pregnancy or immediately postpartum per 100 000 (1:16 000). Almost 60% of women survived. Amongst antenatal women, the leading cause of collapse was a complication of anaesthesia, predominantly because of cardiovascular complications of regional anaesthesia or analgesia. Women who died were more likely to have collapsed at home, more likely to have been moved prior to perimortem caesarean section, and had a longer time between collapse and delivery. Performance of perimortem

caesarean section was more common than anticipated, in 49 cases. Seventy-one percent of babies survived to the point at which the UKOSS form was submitted; no association was found between time to PMCS and infant survival..

Strengths and limitations

The main strength of this study was prospective data collection. This ensured that cases fulfilled strict criteria before analysis; retrospective data from cardiac arrest coding may be inaccurate. Participation in the UKOSS reporting system is voluntary, however, it is an extremely well-established and supported mechanism in the UK, so it is unlikely that cases were missed. Only 66 cases were identified, so the study power to detect what may be clinically important associations as statistically significant is limited.

Interpretation

Sixty six cases of maternal arrest in pregnancy were identified in a 3 year period, with 2 347 670 deliveries during the study interval. The incidence appears similar to UK data from over ten years ago¹, however, it is likely this previous study included women who were recently post-partum. Including post-partum arrests increases the incidence to 6.3 per 100 000 (1:16 000), much closer to figures reported in the United States (1:12 000)⁷. This supports the impression, amongst UK clinicians, that the incidence of maternal cardiac arrest is rising. Complications of anaesthesia were found to cause 24% of all antepartum cardiac arrests, compared to 8% in a retrospective US study ⁷. It is difficult to explain the threefold difference in this complication rate. The inclusion of postpartum cases in the US data will reduce the rate of anaesthetic causes It may be that an

337 increased risk of litigation in the US may dissuade clinicians from assigning an
338 iatrogenic cause in a national audit. A true difference, in clinical anaesthetic
339 practice between the two countries is, however, possible.

340 In 2009 the Royal College of Anaesthetists published the third National Audit
341 Project (NAP 3), looking at UK complications of regional anaesthesia over 12
342 months¹⁰. Obstetric cases represented 315 000 procedures, with one
343 cardiovascular collapse. It is concerning that 13 cases were identified when NAP
344 3 predicts that there should only have been three. However, the reporting
345 criteria for NAP 3 were death or permanent harm, so not all would have qualified
346 for NAP 3, preventing direct comparison.

347 There may be a requirement to review training, supervision and support within
348 obstetric anaesthesia and our findings suggest that further study of anaesthetic
349 causes of maternal arrest in the UK is warranted.

350 The triennial confidential enquiries into maternal deaths in the UK have
351 repeatedly shown that hypovolaemia, VTE and amniotic fluid embolism are
352 leading causes of direct maternal death and these three conditions are identified
353 as the main non-anaesthetic causes of cardiac arrest in this study. There is a
354 pressing need to improve systems focused on preventing and responding
355 appropriately to these complications, as discussed in a recent MBRRACE
356 report.¹¹

357 These data clearly showed that maternal survival is related to the place of
358 collapse. Current teaching suggests PMCS should be performed within five
359 minutes of maternal cardiac arrest, where cardiac output is not restored^{5,12}, to
360 improve maternal outcome, with potential additional benefit to fetal outcome.

361 Our data supports this, however we must accept that in many women, the delay

362 in PMCS was because they collapsed at home and not due to a delay within a
363 hospital setting. Survival was more likely in babies born to women who survived
364 their cardiac arrest, confirming the best way to resuscitate the fetus is to
365 resuscitate the mother.

366 Survival appeared more likely amongst women with a BMI over 30kg/m². It
367 should be noted, however, that 75% of the anaesthetic cases, who all survived,
368 had a BMI >30kg/m², compared with 25% in the non-anaesthetic group
369 (p=0.001 Fisher's Exact). Regional anaesthesia can be more challenging in obese
370 patients, which may explain the over-representation of this group in the
371 anaesthetic causes of cardiac arrest. These would be medically witnessed
372 arrests, with very rapid ALS and PMCS and survival more likely. This may
373 explain the apparent protective effect of obesity.

374 Mhyre's retrospective data tells us that, in the USA, women who were aged over
375 35, of black origin and cared for under the Medicaid system, were most likely to
376 suffer cardiac arrest⁷. There were no clear demographic markers in our data,
377 with a broad distribution of ages, ethnicities and other demographics,
378 irrespective of maternal outcome. This may simply reflect the difference in
379 sample size between the two studies, but could be due to the difference in access
380 to health care between the USA and the UK, Marginalised groups may not access
381 healthcare for a variety of reasons in the UK, but ability to pay to access care is
382 not one of them.

383 A number of publications have questioned the ability to provide BLS and ALS in a
384 maternity setting¹³⁻¹⁵. This study showed median times to initiation for both of
385 less than one minute following maternal collapse, a testament to the quality of
386 maternity-specific resuscitation training in the UK. This rapid resuscitation did

387 not clearly alter maternal survival rates, however, as we showed the same
388 survival rates as those seen in the recent US datasets⁷. Unfortunately, we cannot
389 assess the quality of the CPR, nor the difference in case severity between studies,
390 therefore, the survival rates cannot be fully compared, as we cannot be certain
391 the populations are similar.

392 Manual uterine displacement is preferred by most resuscitation councils to
393 relieve aortocaval compression^{16,17}. This was rarely done, offering an
394 opportunity for improvement in subsequent training. Dutch data suggest a
395 reduction in the reluctance to perform PMCS as a result of maternity-specific
396 training , however, few were done within the prescribed five minutes and
397 overall maternal survival was poor³. American data show that up to one third of
398 women who arrest die with their baby still in utero¹²We have shown a very
399 different approach in the UK; . 49 of the 66 women had a PMCS. Of the 17
400 remaining women, only two (7% of non-surviving women) failed to be delivered
401 by PMCS when they could have been, one because of lack of equipment and one
402 who died at home. This is approaching a five-fold improvement when compared
403 with the American data¹². Consultants were involved in the majority of decisions
404 to perform PMCS and conducted most of them, in keeping with the move to
405 involve senior clinicians. Over 60% of PMCS were performed within 5 minutes
406 of unresponsive cardiac arrest, very different to the Dutch and US data, perhaps
407 reflecting the influence of UK training courses^{3,12}. Whilst much of this may be
408 due to awareness and attitude changes, innovations such as the availability of a
409 surgical knife on the resuscitation trolley and recognising the need to perform
410 PMCS at the site of collapse, have undoubtedly enhanced clinical performance.

A quarter of arrests occurred pre-hospital, with 68% of those having PMCS performed in the emergency department, demonstrating clear clinician preparedness to perform PMCS. Nonetheless, we still saw some women in hospital being unnecessarily moved for their PMCS. The equipment required for this intervention is minimal and does not require a theatre. CPR quality will deteriorate with transfer.

Conclusion This study shows that maternal cardiac arrest is rare. A high proportion of women received timely resuscitation and perimortem caesarean section and survival rates approach 60%. Training in specific arrest management should continue to be performed regularly. Almost a quarter of arrests were due to anaesthetic causes, which warrants further investigation in the future; it may have significant implications on the requirement for resident senior obstetric anaesthetic cover on the delivery suite..

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Disclosure of interests

VB and PS are members of the MOET working group for the Advanced Life Support Group (ALSG), with PS being the Anaesthetic Chair of the working group.

Contribution to authorship

VB conceived the idea and worked on the literature search with PS. VB, MK and PS all contributed to the study design and writing of the manuscript. The majority of the analysis was by PS, with further critical review by MK and VB.

Details of ethics approval

The Yorkshire and Humber research ethics committee approved this study (11/YH/0202) in Bradford on 29/06/2011.

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Table 1: Characteristics of women who survived or died following cardiac arrest. Data shown as number (% of those with data) except for gestation, presented as median (range). Unadjusted and adjusted odds ratios (OR) with (95% CI's) for associations between sociodemographic variables and survival after cardiac arrest are included.

	All women	Women who survived (N=38)	Women who died (N=28)	p-value	Unadjusted		Adjusted	
					OR	p-value	OR	p-value
Age <35 >35	40 (61) 26 (39)	22 (33) 16 (24)	18 (27) 10 (16)	0.59	1.00 1.31(0.48,3.58)	0.600	**	**
Ethnicity White British Other	35 (53) 31 (47)	17 (26) 21 (32)	18 (27) 10 (15)	0.12	1.00 2.22(0.82,6.06)	0.118	1.00 2.74(0.78,9.67)	0.117
BMI kg/m ² <30 ≥30	38 (60) 25 (40)	18 (29) 19 (30)	20 (31) 6 (10)	0.02	1.00 3.52(1.15,10.75)	0.027	1.00 5.86(1.38,24.97)	0.017
Paid employment No Yes	31 (49) 32 (51)	16 (25) 20 (32)	15 (24) 12 (19)	0.38	1.00 1.56(0.57,4.27)	0.384	**	**
Smoked in pregnancy No Yes	51 (80) 13 (20)	29 (45) 8 (13)	22 (34) 5 (8)	0.43	1.00 1.03(0.29,3.67)	0.968	**	**
Gestation at arrest (completed weeks)	37(20-42)	38(20-42)	35(20-41)	0.03	1.09(0.99,1.19)	0.084	1.09(0.98,1.20)	0.117

*Non-white British included; White Irish 1, White other 3, Indian 4, Pakistani 4, Bangladeshi 4, Asian other 3, Caribbean 2, African 8, Black other 1 and Chinese 2. ** Not included in multivariable model as not statistically significant at p<0.2 on univariable analysis

Table 2: Time to emergency procedures in minutes, median (range), following maternal collapse. Mann-Whitney U tests for non-parametric data were applied.

	Women who survived (n=38)	Women who died (n=28)	P value
Collapse to BLS	0(0-17)	0(0-23)	p=0.28
Collapse to ALS	1(0-36)	0(0-24)	p=0.08
Collapse to PMCS	3(0-39)	12(0-67)	p=0.01

Table 3: Factors and decisions concerning perimortem caesarean section, all groups. Data are presented as number of reports or percentage of all perimortem caesarean sections performed.

PMCS factor	Number of women (n=49)
Decision made by:	
Obstetrician	43
Anaesthetist	1
Other clinician	2
Missing	3
Operation performed by:	
Obstetrician	46 (26 by Consultant grade)
Other clinician	1
Missing	2
Aseptic precautions:	
None	12
Skin preparation	11
Sterile drapes	6
Sterile gloves	11
Full scrub	8
Sterile gown	4
Antibiotics	5
Time from arrest to PMCS:	
Less than 5 minutes	30/49 (61%)
5 minutes or more	17/49 (35%)
Not known	2/49 (4%)
Scalpel available on resuscitation trolley:	
Yes	27/49 (55%)
No	14/49 (29%)
Not known	8/49 (16%)

Table 4: Suspected and confirmed (at post mortem) causes for women who died and women who survived. Data were available for 59 women. Some women were suspected to have more than one cause, where this is the case both causes have been recorded.

Cause	Women who survived (n=37)	Women who died (N=22)
Presumed pre-mortem causes, n=59		
Cardiac tamponade	1	0
Hypoxia	4	0
Hypovolaemia	5	8
VTE	3	8
Toxic drug cause	1	0
Anaphylaxis	1	0
Sepsis	0	1
Anaesthetic cause	17	0
AFE	4	4
Cardiac cause	5	1
Intracerebral bleed	0	3
Aortic dissection	0	2
Asthma	0	1
Pulmonary artery rupture	0	1
Post mortem causes of collapse, n=19		
AFE		6
Vessel bleed / rupture		5
Thrombembolic		3
Cardiomyopathy		2
Other		3