BJOG An International Journal of Obstetrics and Gynaecology

DOI: 10.1111/1471-0528.14521
www.bjog.org

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

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Accepted 5 December 2016. Published Online 24 February 2017.

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 (PMCS).

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

Setting All UK hospitals with maternity units.

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

Methods Prospective case identification through UKOSS monthly mailing.

Main outcome measures Cardiac arrest in pregnancy, PMCS, maternal death.

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

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

Keywords Cardiac arrest, maternal morbidity, maternal mortality, perimortem caesarean section, resuscitation.

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

Linked article This article is commented on by JM Mhyre. To view this mini commentary visit https://doi.org/10.1111/1471-0528.14569.

Please cite this paper as: Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. BJOG 2017; DOI: 10.1111/1471-0528.14521.

Introduction

Estimates suggest that cardiac arrest in pregnancy occurs in around 1 in 30 000 pregnancies.[1] However, there has been no recent assessment of this rate despite the increasing age and morbidity of the antenatal population in the UK. The UK Confidential Enquiry into Maternal Deaths report for the 2003–5 triennium noted 52 women who had undergone perimortem caesarean section (PMCS).[2] The outcome for the mother in these cases was clearly fatal, as they were identified from within the population of women who died. The number of women managed with PMCS had doubled since the previous report. A retrospective study[3] in the Netherlands, assessing 15 years of data up to 2008, also described an increase in the use of PMCS in maternal cardiac arrest, citing the introduction of the Managing Obstetric Emergencies & Trauma (MOET) course as partly responsible for this shift in practice. PMCS was performed later than the optimal 5 minutes[4] and outcomes were poor.

Perimortem caesarean section is now taught on the MOET and similar courses across Europe.[5] The importance of rapid delivery after cardiac arrest for maternal benefit is becoming a widely accepted practice. The rationale for performing PMCS within 5 minutes of arrest is that this will minimise the risk of maternal neurological damage from cerebral anoxia.[5] Irreversible anoxic brain injury occurs more quickly in pregnant than nonpregnant women.[5] Emptying the uterus in maternal cardiac arrest can result in rapid improvement, with return of spontaneous circulation.[6] There may also be a chance of neonatal survival. It is perceived that there is still significant delay in the decision making to perform a PMCS.[3] There may be several factors affecting this delay, for instance lack of senior presence at the time, awaiting specialty input in an emergency department, reluctance to perform the procedure in a nonsterile environment, fear of medicolegal 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 PMCS, in the UK over a 3-year period 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 series.[7]

Methods

Using the UKOSS, we conducted a national, prospective descriptive study. The UKOSS 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 elsewhere.[8] 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 that 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 so 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 among 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 gather 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 postpartum 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 before 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 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 3 years of the study. Data were tested for distribution and tested for between-group differences, using appropriate parametric and nonparametric 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 Corporation, Armonk, NY, USA) 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 3-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. Hence, 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% CI 30–55%). Table 1 shows the characteristics of those who survived and those who died. Only maternal body mass index (BMI) of ≥30 kg/m^2 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 n = 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 four (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 BLS, advanced life support (ALS) and 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,

Table 1. Characteristics of women who survived or died following cardiac arrest

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

Data shown as number (% of those with data) except for gestation, presented as median (range). Unadjusted and adjusted odds ratios (OR) with (95% CI) for associations between sociodemographic variables and survival after cardiac arrest are included.

*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.

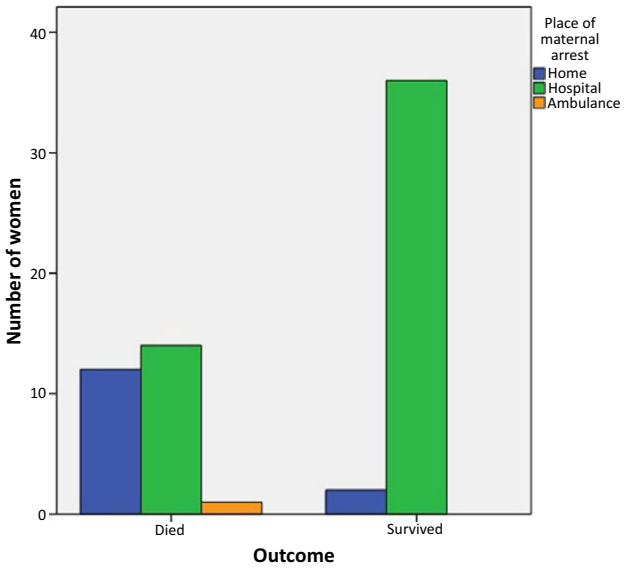

Figure 1. The place where the cardiac arrest occurred (n = 66). P < 0.001 chi-square test.

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 minutes [interquartile range (IQR) 2.5–17.5] compared with 16 minutes (IQR 6.5–43.5) 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 (n = 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.

PMCS details

Forty-nine women had a PMCS performed, of which 11 were performed in the emergency department. Seventeen women did not have a PMCS performed for the following reasons: cardiac output restored (n = 6), gestation <20 weeks (n = 6), gestation not considered to be interfering with cardiopulmonary resuscitation (n = 1), gestation unknown (n = 1), no equipment available (n = 1) and woman died at home (n = 1). Only two (7%) of the 28 women who died did not have an appropriate PMCS who should have had one, one of these women had already died at home.

Table 2. Time to emergency procedures in minutes, median (range), following maternal collapse

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

Mann–Whitney U tests for nonparametric data were applied.

Twenty-two women (45%) were moved from the place of collapse for the following reasons: transfer from home to hospital (n = 11), cardiac output restored (n = 4), need for equipment (n = 2), theatre already prepared at time of collapse (n = 2), already en route to theatre (n = 1), for better surgical access (n = 1) or because of a need for theatre staff (n = 1). Of the 25 women not moved for their PMCS, 18 (72%) survived, whereas of the 22 women who were moved eight (36%) survived. Survival appeared significantly more likely when the woman was not moved from the site of collapse (Figure 2) and when PMCS was performed promptly (Table 2). However, allowing for those women who were transferred for a medical indication, either from home to the emergency department or because of returning cardiac output requiring general anaesthesia,

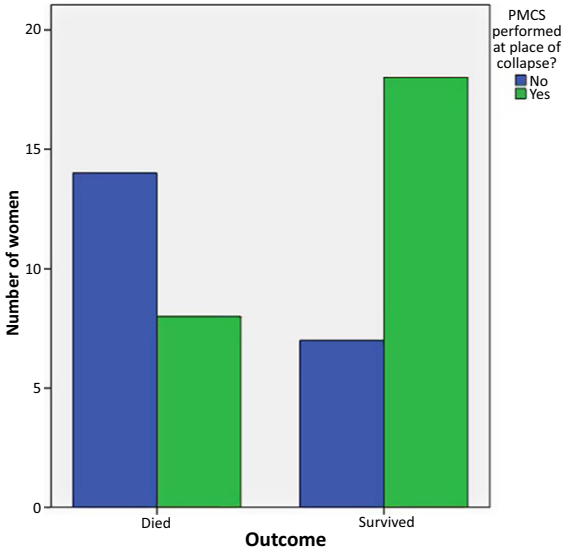

Figure 2. The site of perimortem caesarean section (n = 47, as data were missing for two cases of PMCS). P < 0.001 chi-square test.

only seven women had avoidable moves, of whom three (43%) died. This figure was not statistically significant from the number who survived such a move ($P = 1.0$ Fisher's Exact Test).

The decision to perform a PMCS was taken predominantly by obstetricians and was performed by senior obstetricians in most 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 5 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 were 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 ($n = 3$), cardiovascular collapse following epidural top-up ($n = 3$), total spinal anaesthetic (from de novo intrathecal block) ($n = 10$) and other anaesthetic-related reasons ($n = 1$). All of 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. Although some had more than one cause of morbidity, of the primary morbidities reported, six

Table 3. Factors and decisions concerning perimortem caesarean section, all groups

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%)

Data are presented as number of reports or percentage of all perimortem caesarean sections performed.

Table 4. Suspected and confirmed (at post mortem) causes for women who died and women who survived

Cause	Women who survived ($n = 37$)	Women who died ($n = 22$)
Presumed premortem causes ($n = 59$)		
Cardiac tamponade	1	0
Hypoxia	4	0
Hypovolaemia	5	8
Venous thromboembolism	1	7
Toxic drug cause	1	0
Anaphylaxis	1	0
Sepsis	0	1
Anaesthetic cause	17	0
Amniotic fluid embolism	5	3
Cardiac cause	5	1
Intracerebral bleed	0	3
Aortic dissection	0	2
Asthma	0	1
Pulmonary artery rupture	0	1
Postmortem causes of collapse ($n = 19$)		
Amniotic fluid embolism		6
Vessel bleed/rupture		5
Thrombembolic		3
Cardiomyopathy		2
Other		3

Data were available for 59 women. Some women were suspected of having more than one cause, where this is the case both causes have been recorded.

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 days. 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 days. The maternal median days in hospital was eight (range 3–147).

Data on maternal morbidity or mortality were 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 5 minutes compared with seven of ten babies (70%) when PMCS occurred >5 minutes after cardiac arrest ($P = 0.059$), noting the association between location of maternal collapse and delay in PMCS. Birth weights ranged from 1766 to 2744 g in the babies of mothers who died compared with from 2489 to 3329 g in the babies of women who survived, 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 neonatal ICU was 13 days (range 3–101) for babies of mothers who died compared with 4 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. Among 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 before PMCS, and had a longer time between collapse and delivery. Performance of PMCS was more common than anticipated, in 49 cases. Seventy-one per cent 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 10 years ago;[1] however, it is likely that this previous study included women who were recently postpartum. Including postpartum arrests increases the incidence to 6.3 per 100 000 (1:16 000), much closer to figures reported in the USA (1:12 000).[7] This supports the impression, among 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 with 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 increased risk of litigation in the USA may dissuade clinicians from assigning an iatrogenic cause in a national audit. A true difference in clinical anaesthetic practice between the two countries is, however, possible.

In 2009 the Royal College of Anaesthetists published the third National Audit Project (NAP 3), looking at UK complications of regional anaesthesia over 12 months.[10] Obstetric cases represented 315 000 procedures, with one cardiovascular collapse. It is concerning that 13 cases were identified when NAP 3 predicts that there should only have been three. However, the reporting criteria for NAP 3 were death or permanent harm, so not all would have qualified for NAP 3, preventing direct comparison.

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

The triennial confidential enquiries into maternal deaths in the UK have repeatedly shown that hypovolaemia, venous thromboembolism and amniotic fluid embolism are leading causes of direct maternal death and these three conditions are identified as the main nonanaesthetic causes of cardiac arrest in this study. There is a pressing need to improve systems focused on preventing and responding appropriately to these complications, as discussed in a recent MBRRACE report.[11]

These data clearly showed that maternal survival is related to the place of collapse. Current teaching suggests that PMCS should be performed within 5 minutes of maternal cardiac arrest, where cardiac output is not restored,[5,12] to improve maternal outcome, with potential additional benefit to fetal outcome. Our data support this; however, we must accept that in many women, the delay in PMCS was because they collapsed at home and not due to a delay within a hospital setting. Survival was more likely in babies born to women who survived their cardiac arrest, confirming the best way to resuscitate the fetus is to resuscitate the mother.

Survival appeared more likely among women with a BMI > 30 kg/m^2. It should be noted, however, that 75% of the anaesthetic cases, who all survived, had a BMI > 30 kg/m^2, compared with 25% in the nonanaesthetic group ($P = 0.001$ Fisher's exact test). Regional anaesthesia can be more challenging in obese patients, which may explain the over-representation of this group in the anaesthetic causes of cardiac arrest. These would be medically witnessed arrests, with very rapid ALS and PMCS and survival more likely. This may explain the apparent protective effect of obesity.

The retrospective data of Mhyre et al.[7] tell us that, in the USA, women who were aged over 35 years, of black origin and cared for under the Medicaid system, were most likely to suffer cardiac arrest. There were no clear demographic markers in our data, with a broad distribution of ages, ethnicities and other demographics, irrespective of maternal outcome. This may simply reflect the difference in sample size between the two studies, but could be due to the difference in access to health care between the USA and the UK. Marginalised groups may not access healthcare for a variety of reasons in the UK, but ability to pay to access care is not one of them.

A number of publications have questioned the ability to provide BLS and ALS in a maternity setting.[13–15] This study showed median times to initiation for both of <1 minute following maternal collapse, a testament to the quality of maternity-specific resuscitation training in the UK. This rapid resuscitation did not clearly alter maternal survival rates, however, as we showed the same survival rates as those seen in the recent US data sets.[7] Unfortunately, we cannot assess the quality of the cardiopulmonary resuscitation, nor the difference in case severity between studies, therefore, the survival rates cannot be fully compared, as we cannot be certain the populations are similar.

Manual uterine displacement is preferred by most resuscitation councils to relieve aortocaval compression.[16,17] This was rarely done, offering an opportunity for improvement in subsequent training. Dutch data suggest a reduction in the reluctance to perform PMCS as a result of maternity-specific training; however, few were carried out within the prescribed 5 minutes and overall maternal survival was poor.[3] American data show that up to one-third of women who arrest die with their baby still in utero.[12] We have shown a very different approach in the UK; 49 of the 66 women had a PMCS. Of the 17 remaining women, only two (7% of non-surviving women) failed to be delivered by PMCS when they could have been, one because of lack of equipment and one who died at home. This is approaching a fivefold improvement when compared with the American data.[12] Consultants were involved in the majority of decisions to perform PMCS and conducted most of them, in keeping with the move to involve senior clinicians. Over 60% of PMCS were performed within 5 minutes of unresponsive cardiac arrest, very different to the Dutch and US data, perhaps reflecting the influence of UK training courses.[3,12] Although much of this may be due to awareness and attitude changes, innovations such as the availability of a surgical knife on the resuscitation trolley and recognising the need to perform 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 PMCS 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 for the requirement for resident senior obstetric anaesthetic cover on the delivery suite.

Acknowledgements

The authors acknowledge the contributions of Laura Wijeratne, who assisted with the literature review for our grant application and Eamonn Breslin, who assisted with initial statistical analysis. Gillian Santorelli's statistical input was invaluable. The authors would also like to thank the UKOSS reporting clinicians, and their teams, who notified cases and completed data collection forms. This study would not have been possible without their contributions.

Disclosure of interests

Full disclosure of interests available to view online as supporting information.

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.

Funding

This study was funded by a grant from Wellbeing of Women. ■

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