34 Cardiac arrest in obstetric patients receiving anaesthetic care



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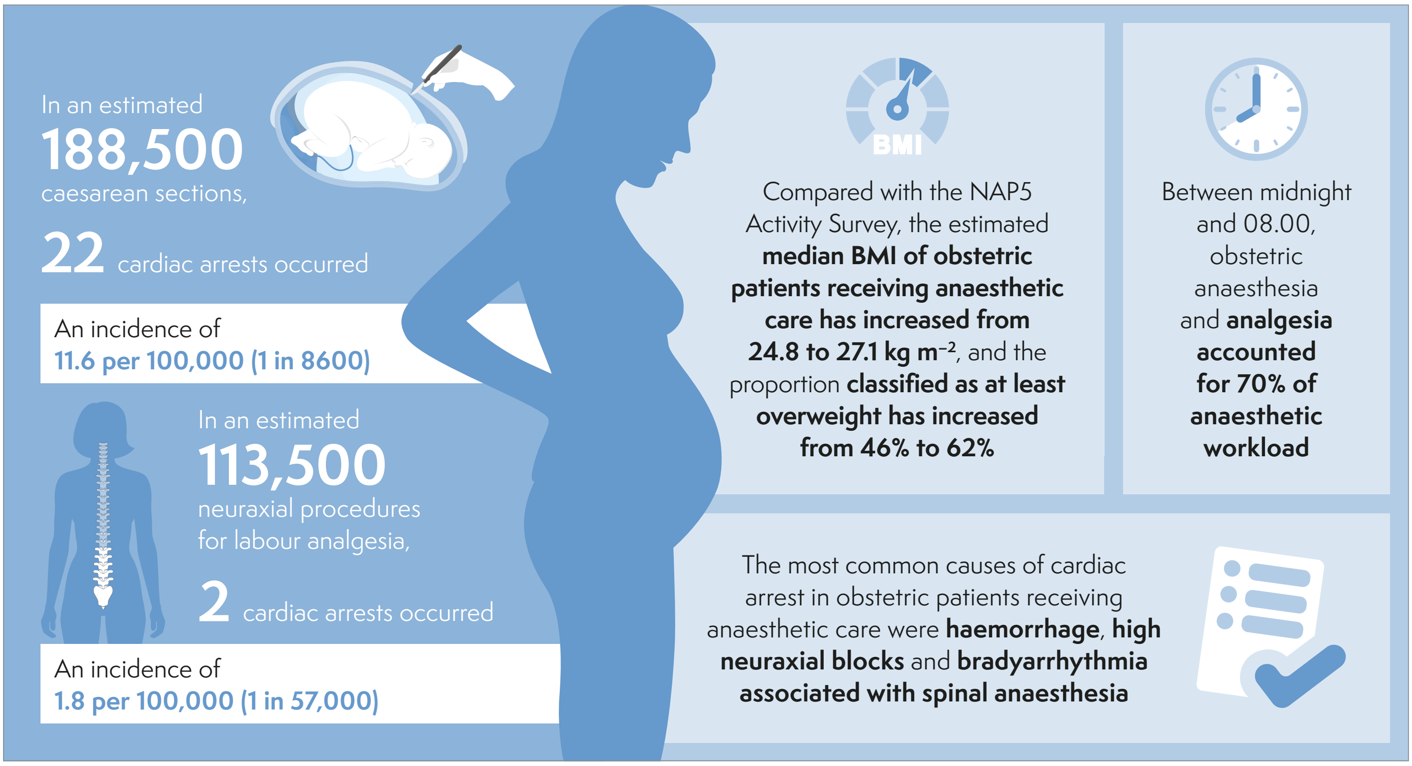
Key findings

- Obstetric anaesthetic activity accounted for 13% of all anaesthetic cases in the Activity Survey. Scaled up, this equates to approximately 356,153 obstetric anaesthetic encounters per year (188,500 caesarean sections, 113,000 labour analgesia, 54,000 other procedures).
- Between midnight and 08.00, obstetric anaesthesia and analgesia accounted for 70% of anaesthetic workload.
- There were 28 perioperative cardiac arrests reported to the Seventh National Audit Project (NAP7) in obstetric patients, accounting for 3.2% of all cases. This gives an incidence of 7.9 per 100,000 (1 in 12,700) anaesthetic encounters in the obstetric population. Cardiac arrests in this population occurred at a much lower rate than other anaesthetic subspecialties in the NAP7 cohort.
- Twelve (43%) cardiac arrests were associated with neuraxial anaesthesia for caesarean section or instrumental delivery, eight (28%) with general anaesthesia for caesarean section or operative management of haemorrhage and five (18%) with general and neuraxial anaesthesia for caesarean section or operative management of haemorrhage.
- Two patients had a cardiac arrest associated with the use of labour neuraxial analgesia, giving an incidence of cardiac arrest associated with neuraxial analgesia of 1.8 per 100,000 (1 in 56,500). Another patient had a cardiac arrest associated with an epidural that was placed for labour analgesia and used later for a postnatal procedure.
- There were 22 cardiac arrests in women undergoing caesarean section: an incidence, of 11.7 in 100,000 (1 in 8,600).
- Five (18%) women who had a cardiac arrest died: a mortality rate of 1.4 per in 100,000 (1 in 71,000) anaesthetic interventions.
- In obstetric patients who were receiving anaesthetic care, haemorrhage, high neuraxial block and bradyarrhythmia were the three most frequent causes of cardiac arrest, accounting for 19 (68%) of the total 28 cases.
- The incidence of cardiac arrest for all obstetric patients receiving regional anaesthesia was 5.9 per 100,000 (1 in 17,000) and for all obstetric patents receiving general anaesthesia, 82 per 100,000 (1 in 1220).
- Care during and after cardiac arrest was judged to be good in three-quarters of cases, while care before cardiac arrest was judged good in 36% of cases and poor in 18%. This contrasts with the overall NAP7 dataset, where care before cardiac arrest was judged good in 48% of cases and poor in 11%.
- Anaesthesia care was judged a key cause of cardiac arrest in 68% obstetric cardiac arrests (versus 40% in all NAP7 cases) and was the most common key cause, followed by patient factors (54%) and surgical factors (29%).
- The body mass index (BMI) of the obstetric population who receive anaesthetic care has increased: compared with the NAP5 Activity Survey, the median BMI of obstetric patients has increased from 24.8 $kg\ m^{-2}$ to 27.1 $kg\ m^{-2}$. The proportion classified as at least overweight increased from 46% to 62%.
- Compared with women in the NAP7 Activity Survey, women who had a perioperative cardiac arrest were more likely to be overweight or in obesity categories 1, 2 or 3.
- The obstetric patient population who experienced a cardiac arrest, compared with patients in the NAP7 Activity Survey, were more commonly Black (21% vs 6%) and less commonly White (54% vs 76%).
- Two reports stated that the cardiac arrest case led to psychological impact on the lead anaesthetist, affecting their ability to deliver patient care. In the Baseline Survey, among anaesthetists whose most recent experience of perioperative cardiac arrest was in an obstetric setting, more than 5% reported an impact on their subsequent patient care delivery.



What we already know

Cardiac arrest in an obstetric patient is a unique clinical emergency because two lives are immediately at risk. When this occurs before delivery, if there is no return of circulation within four minutes, a perimortem caesarean section should be undertaken simultaneously with cardiopulmonary resuscitation (CPR), to improve the chance of successful maternal resuscitation (RCUK 2021).

Cardiac arrest in pregnancy (before delivery) was investigated in 2017 in a prospective observational study using the UK obstetric surveillance system (Beckett 2017). The authors identified an incidence of 2.78 per 100,000 maternities (1 in 36,000; 95% confidence interval, CI, 2.2–3.6), with anaesthesia (local anaesthetic toxicity and high neuraxial block) being the single most common cause. An analysis from the United States of the Nationwide Inpatient Sample (1998–2011) showed that maternal cardiac arrest complicated 1 in 12,000 or 8.5 per 100,000 hospitalisations for delivery (95% CI 7.7–9.3 per 100,000; Mhyre 2014). The most common causes were haemorrhage, heart failure, amniotic fluid embolism, and sepsis. Another US study investigating characteristics and outcomes of in-hospital maternal cardiac arrest found that 30% of cases occurred in the delivery suite (Zelop 2018).

A significant proportion of anaesthetic care in obstetrics relates to the provision of labour analgesia, predominantly neuraxial techniques. While remifentanil patient-controlled analgesia (PCA) may be used as an alternative to epidural analgesia, concerns exist about the risks associated with its use, including respiratory depression and maternal cardiac arrest (Muchatuta 2013). In an analysis of a remifentanil PCA database across 31 hospitals and 5,740 patients, there were no cases where CPR was required (Melber 2019). Evidence suggests that it is used in only a very small number of deliveries (Bamber 2020a).

What we found

Baseline Survey

Almost three-quarters (139 of 188, 74%) of responding anaesthetic departments providing adult anaesthesia also covered obstetric units. Around one-third of these (44 of 139) were reported by the Local Coordinator to be in a remote location where help from another anaesthetist may not be immediately available (Chapter 9 Organisational survey).

Half (69 of 139, 50%) of obstetric units offered remifentanil PCA for labour analgesia, of which 23% (16 of 69) were routinely using this service, 72% (50 of 69) occasionally and in 4% (3 of 69) the service was being set up. How often remifentanil PCA was actually used was not captured by this survey.

In the individual anaesthetists' Baseline Survey, 23% of consultant and specialist, associate specialist and specialty grade (SAS) anaesthetists stated that their subspecialty area of expertise was obstetric anaesthesia (Chapter 10 Anaesthetists Survey). Of 4,664 anaesthetists, 189 (4%) reported that the most recent perioperative cardiac arrest they had attended or managed occurred in the obstetric theatre or labour ward. The event had an impact on their ability to deliver patient care in 10 of 181 (5.5%) respondents to this question and 17 (9.4%) were unsure of the impact or preferred not to say (see Chapter 10 Anaesthetists Survey and Chapter 17 Aftermath and learning).

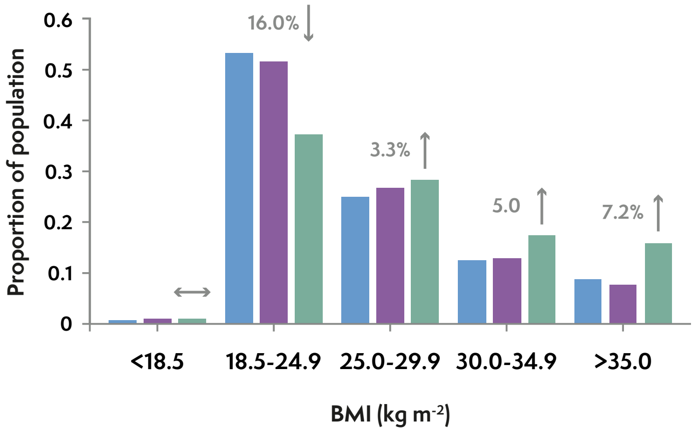
Activity Survey

There were 3,176 obstetric cases recorded in the Activity Survey (caesarean sections, labour analgesia and 'other'), which equates to approximately 356,153 cases per year in the UK. Considering all obstetric patients, 742 (23%) were described as ASA 1, 2,226 (70%) as ASA 2 and 208 (6.5%) as ASA 3 or above. In terms of age, 26 (0.8%) patients were 18 years or under, 487 (15%) 19–25 years, 2,039 (64%) 26–35 years and 624 (20%) 36 years or older. In 55% of obstetric patients with a BMI of 40 kg m^{-2} or above, ASA was underscored as ASA 2 (and in 3% as ASA 1) rather than ASA 3.

Just over one-third (37%) of patients were of normal weight, 28% were overweight and 33% were obese. Over the past 10 years, the BMI of the obstetric population has increased. When compared with the NAP5 and NAP6 activity surveys, the median BMI of obstetric patients has progressively increased from 24.8 kg m^{-2} to 27.1 kg m^{-2}, and the proportion classified as overweight or higher increased from 46% of the population to 62%, with the steepest rise observed in patients with BMI over 35 kg m^{-2} in the order of 7.2% (Figure 34.1).

Anaesthesia care in obstetrics accounted for 13% of all anaesthetic activity across the UK, with the majority of cases being performed during the day, accounting for 7.5% of total workload, but a high out-of-hours workload (Figure 34.2). In the evening (18.00–23.59 hours), obstetrics accounted for 31% of all anaesthetic activity and between 00.01 and 08.00 hours, 70% of all anaesthetic activity. This distribution of anaesthetic activity is similar to previous NAP reports.

Figure 34.1 BMI distribution of obstetric patients from the Activity Surveys of NAP5, 6 and 7. NAP5 2013 ■; NAP6 2016 ■; NAP7 2021 ■. Proportions show the relative change in the population proportion within the group between NAP5 and NAP7. ↑, increase; ↓, decrease; ↔, no change. Percentages may not total 100 due to rounding.



Of the obstetric anaesthetic activity recorded, 1,681 (53%) were caesarean sections, 1,010 (32%) were for labour neuraxial analgesia and 485 (15%) for other surgical procedures. Use of remifentanil PCA was not included in the Activity Survey. For labour neuraxial analgesia, most patients received an epidural

Figure 34.2 Percentage of anaesthetic workload by specialty and time: NAP7 Activity Survey. ENT, ear, nose and throat; GI, gastrointestinal.

Specialty	Daytime (0800-1759)	Evening (1800-2359)	Night (0000-0759)	Total
	%	%	%	%
Orthopaedics - cold/elective	11.4	1.9	0.3	10.3
General surgery	9.1	14.1	7.0	9.3
Orthopaedics - trauma	9.2	7.6	2.1	8.7
Urology	8.9	5.9	2.3	8.4
Gynaecology	8.7	4.1	1.2	8.1
Obstetrics: Caesarean section	5.4	15.0	25.5	7.0
ENT	6.1	1.5	1.1	5.6
Abdominal: lower GI	4.6	7.6	3.7	4.7
Ophthalmology	4.8	1.0	0.3	4.3
Obstetrics: labour analgesia	2.1	15.9	29.8	4.2
Plastics	3.3	1.9	0.7	3.1
Dental	3.4	0.1	0.0	3.1
Maxillofacial	2.6	1.3	0.4	2.4
Abdominal: upper GI	2.3	1.2	0.9	2.2
Obstetrics: other	1.0	7.8	14.3	2.0
Others combined	17.1	13.3	10.5	16.5
Total	100	100	100	100

(855 of 1,010, 85%), followed by CSE (62 of 1,010; 6.1%), spinal (27 of 1,010, 2.7%) or another unspecified regional block (66 of 1,010, 6.5%). Annual activity based on the Activity Survey is estimated as 188,500 caesarean sections, 113,000 neuraxial blocks for labour analgesia, 54,000 other obstetric procedures, giving a total of 355,500 obstetric anaesthetic procedures.

Cases

Obstetric anaesthesia and cardiac arrest in context

There were 28 cases of cardiac arrest in the obstetric setting. This represents 3.2% of all cardiac arrests reported to NAP7. Obstetric anaesthesia accounted for 13.1% of all anaesthetic activity and therefore this population is approximately four times less likely to have a cardiac arrest during anaesthesia care than non-obstetric patients (Figures 34.3 and 34.4). Incidences of cardiac arrest in an obstetric setting is shown in Table 34.1

Twelve cardiac arrests were associated with neuraxial anaesthesia for caesarean section or instrumental delivery, two with neuraxial anaesthesia for labour analgesia, eight with general anaesthesia for caesarean section or operative management of haemorrhage and five with general and neuraxial anaesthesia. One was associated with top-up of an epidural placed for labour analgesia but used later for a postnatal procedure.

The incidence of cardiac arrest amongst obstetric patients receiving regional anaesthesia was 5.9 per 100,000 (1 in 17,000) and in obstetric patents receiving general anaesthesia 82 per 100,000 (1 in 1,220).

Causes and outcomes of perioperative cardiac arrest

The causes of cardiac arrest in obstetric patients is shown in Table 34.2. Seven patients had a cardiac arrest due to haemorrhage. In six of these cases, the panel judged that the extent of the haemorrhage was not recognised, with inadequate resuscitation likely to have contributed to the cardiac arrest. In several cases, the local report suggested anaphylaxis as the cause, but the panel disagreed and considered cardiac arrest to have been probably secondary to conduct of general anaesthesia, particularly in the context of hypovolaemia.

Six patients had a cardiac arrest associated with a high neuraxial block. In two of these, cardiac arrest occurred during a top-up with a low-dose local anaesthetic and opioid solution for labour analgesia. In both patients, the top-up was the first dose after siting of the epidural catheter. One of these patients subsequently required perimortem caesarean section with good maternal and neonatal outcomes. The other patient was successfully resuscitated without perimortem caesarean section. Both patients received a dose of 15–20 mg bupivacaine (given as a 0.1% solution). A third patient received an epidural bolus to facilitate surgical intervention. The subsequent high neuraxial

Figure 34.3 Number of cases of cardiac arrest by specialty. ENT, ear, nose and throat; GI, gastrointestinal. Immediate ■, Urgent ■, Expedited ■, Elective ■, N/A ■.

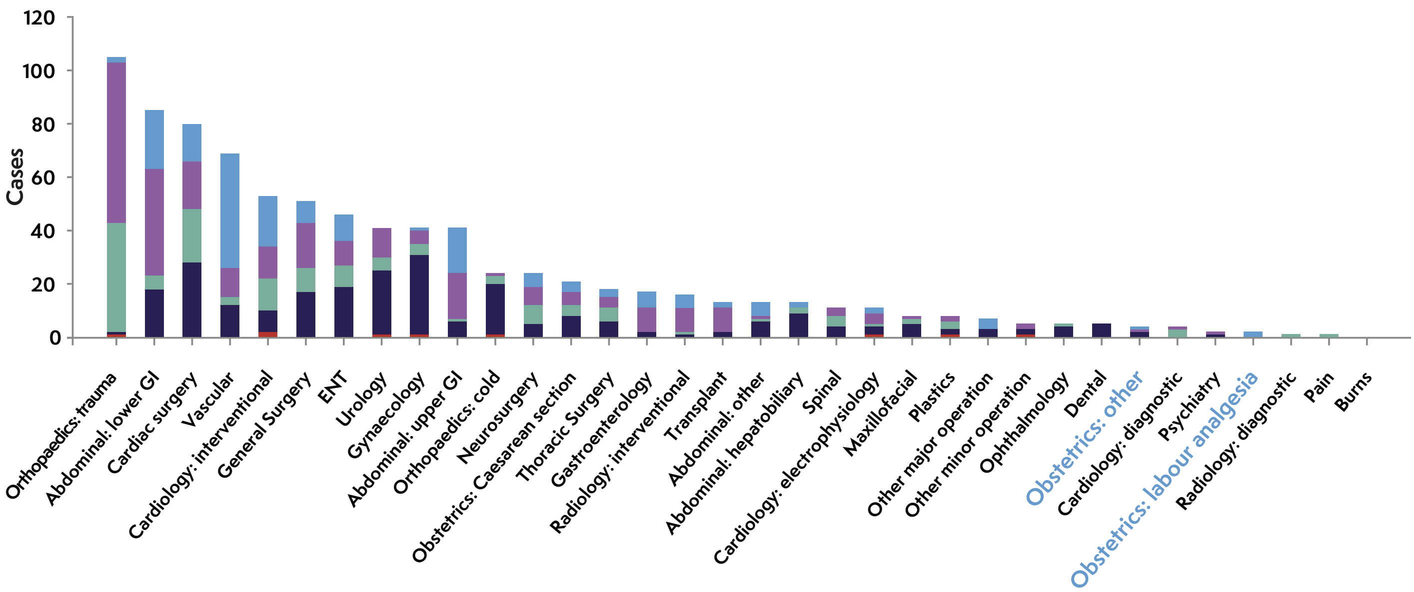


Figure 34.4 Relative risk of cardiac arrest by specialty. Size of coloured circle indicates magnitude of difference between proportion of cases in Activity Survey and case registry. Green circles are relatively underrepresented in the case registry and red circles relatively overrepresented. Dashed lines represent 2 : 1, 1 : 1 and 1 : 2 ratios.

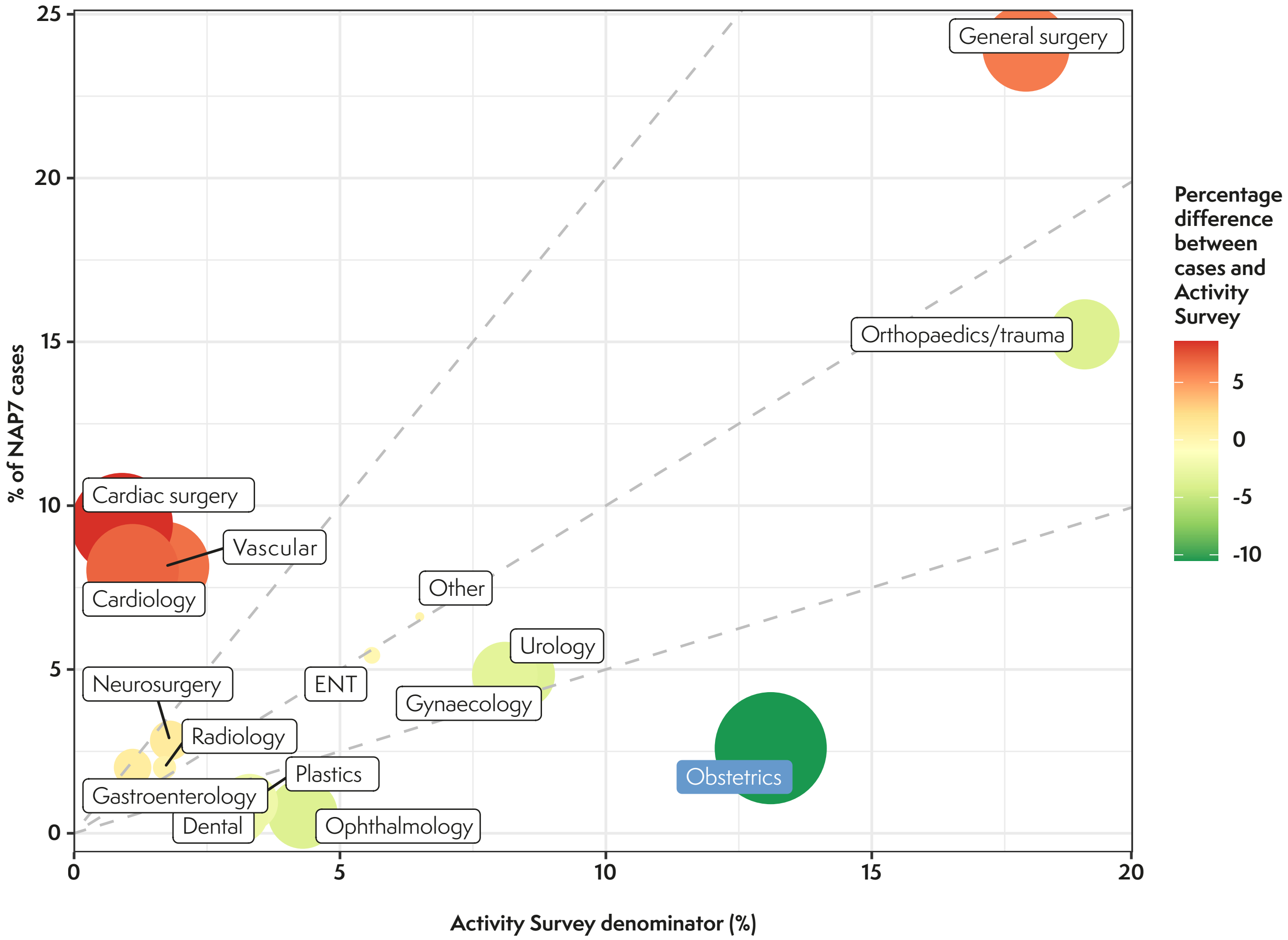


Table 34.1 Incidence of cardiac arrest in different obstetric settings. Annual activity is estimated using a multiplier of 112.14 as described in Chapter 6 Methods.

Setting	Cardiac arrests (*n*)	Cases in NAP7 Activity Survey (*n*)	Estimated annual denominator	Incidence per 100,000 (95% confidence interval)	Incidence as 1 per (95% CI)	Deaths, *n*=28 (*n*)
All obstetric anaesthetic care	28	3176	355,500	7.9 (5.2–11.4)	12,700 (8800–19,100)	5
Labour neuraxial analgesia	2	1010	113,000	1.8 (1.0–6.4)	56,500 (15,600–100,000)	0
Anaesthesia for caesarean section*	22	1681	188,500	11.7 (7.3–17.7)	8600 (5700–13,700)	4
Other obstetric cases	4	485	54,000	7.4 (2.0–19)	13,500 (5300–50,000)	1

* If using NHS Digital data for English births (scaled up for UK) of 202,500 caesarean sections: incidence 10.9 (6.8–16.4) per 100,000, 1 in 9200 (6100–14,700). https://digital.nhs.uk/data-and-information/publications/statistical/maternity-services-monthly-statistics

block was believed to be caused by catheter migration into the subarachnoid space. A fourth patient developed a high neuraxial block after spinal anaesthesia was undertaken after an epidural top-up failed to provide sufficient anaesthesia for surgical intervention. The dose of local anaesthetic used in the spinal was described by the Local Coordinator as 'reduced' compared with the usual doses used for spinal anaesthesia for operative delivery, but no further information was provided. Two patients developed a high block associated with de novo spinal anaesthesia for caesarean section.

A woman on the labour ward had an epidural sited for analgesia. She received an epidural top-up of low-dose bupivacaine equivalent to over 15 mg. She became hypotensive and then went into cardiac arrest. She had a perimortem caesarean section. Both she and her baby made a full recovery.

Six patients developed a bradyarrhythmia that led to cardiac arrest: four patients developed asystole and two developed profound bradycardias. In five patients, this was associated with spinal anaesthesia for caesarean section, and in the sixth, the patient had received spinal then general anaesthesia. The five patients who had received spinal anaesthesia alone, were receiving phenylephrine infusions at the time of cardiac arrest, and this was judged by the panel to have contributed to the bradyarrhythmia. In two patients, the bradyarrhythmia occurred within 10 minutes of the spinal anaesthetic, but in the remaining four cases, up to 30 minutes after siting the spinal block.

A woman received a spinal anaesthetic for a planned caesarean section. A phenylephrine infusion was used to manage spinal hypotension. Shortly after delivery of the baby, her heart rate decreased dramatically, then progressed to asystole. There was return of circulation with atropine and a short period of cardiopulmonary resuscitation.

Five patients had a cardiac arrest after receiving spinal followed by general anaesthesia. General anaesthesia was required because of haemorrhage or inadequate neuraxial anaesthesia. In all five of these cases cardiac arrest occurred immediately after induction of general anaesthesia.

A woman received a spinal anaesthetic for a planned caesarean section. Bleeding was brisk after delivery, and a massive haemorrhage was declared. General anaesthesia was induced and immediately after induction, she had a cardiac arrest. She was resuscitated with adrenaline and fluids. The Local Coordinator attributed the cause of cardiac arrest to hypovolemia compounded by general anaesthesia, with which the NAP7 panel agreed.

Table 34.2 Panel-agreed causes of cardiac arrest in obstetric patients (more than one cause may be attributed to one case); 41 causes were reported for 28 cases

Cause of cardiac arrest	No. of patients affected (*n*=28)	Proportion of patients affected by a particular cause (%)
Major haemorrhage	7	25
High neuraxial block	6	21
Bradyarrhythmia	6	21
Amniotic fluid embolism	4	14
Drug error	2	7.2
Anaphylaxis	1	3.6
Pulmonary embolism	1	3.6
Severe hypoxaemia	1	3.6
Vagal outflow (eg pneumoperitoneum, oculocardiac reflex)	1	3.6
Other	12	42

There were no cases of cardiac arrest associated with remifentanil PCA for labour analgesia or local anaesthetic toxicity.

The key cause of cardiac arrest in obstetric patients receiving anaesthesia care was most commonly anaesthesia in 19 (68%) cases, followed by the patient in 15 (54%) and surgery in 8 (29%) cases (Figure 34.5). The proportion attributed to anaesthesia is higher than for other specialties; in all NAP7 reports, key causes were anaesthesia in 40%, patient factors in 82% and surgery in 35%. When a single key cause of cardiac arrest was highlighted, this was most commonly anaesthesia.

Some 96% of patients (27 of 28) had an initial return of spontaneous circulation but five patients subsequently died. Of the five patients who died, four were associated with caesarean section and one with a non-caesarean obstetric intervention. Three women died from obstetric haemorrhage, one from severe COVID-19, and the cause of death in one woman was unascertained. In one case, the cardiac arrest was part of an inexorable fatal process; in the other cases, it was uncertain if death could have been avoided. In addition to the women who died, based on the National Patient Safety Association outcomes (NPSA 2004), among the remaining 23 obstetric cases, the degree of harm was judged by the review panel as severe in 4 and moderate in 19.

The majority (22 of 28, 79%) of cardiac arrests in obstetric patients occurred after delivery of the baby. In the remaining six cases where the cardiac arrest occurred before delivery, all six neonates survived, with one referred for therapeutic cooling.

Factors associated with perioperative cardiac arrest in obstetric patients

The distribution of ethnicities among obstetric patients who had a cardiac arrest differed from both obstetric patients in the Activity Survey and the rest of the cohort of cardiac arrests reported to NAP7. Black obstetric patients were overrepresented in the cohort who had a perioperative cardiac arrest. In the Activity Survey, 193 of 3,176 (6.1%) obstetric patients were Black or Black British, whereas 6 of 28 (21%) obstetric cardiac arrests occurred in this cohort. Black patients accounted for 21% of obstetric cardiac arrests and 16 (1.9%) of non-obstetric cardiac arrests reported to NAP7. The 'other White' population were also overrepresented, although to a lesser degree; 380 (12%) cases were included in this group, but they accounted for 5 (18%) of 28 cardiac arrests. Patients from 'any Asian' background were not overrepresented, accounting for 427 of 3,176 (13.4%) obstetric cases and 4 (14%) of those having a cardiac arrest. Overall, White patients were underrepresented in the obstetric cohort, accounting for 15 (54%) of obstetric cardiac arrests and 76% of anaesthetic survey obstetric activity.

Figure 34.5 Key cause of obstetric perioperative cardiac arrest: multiple causes may be cited

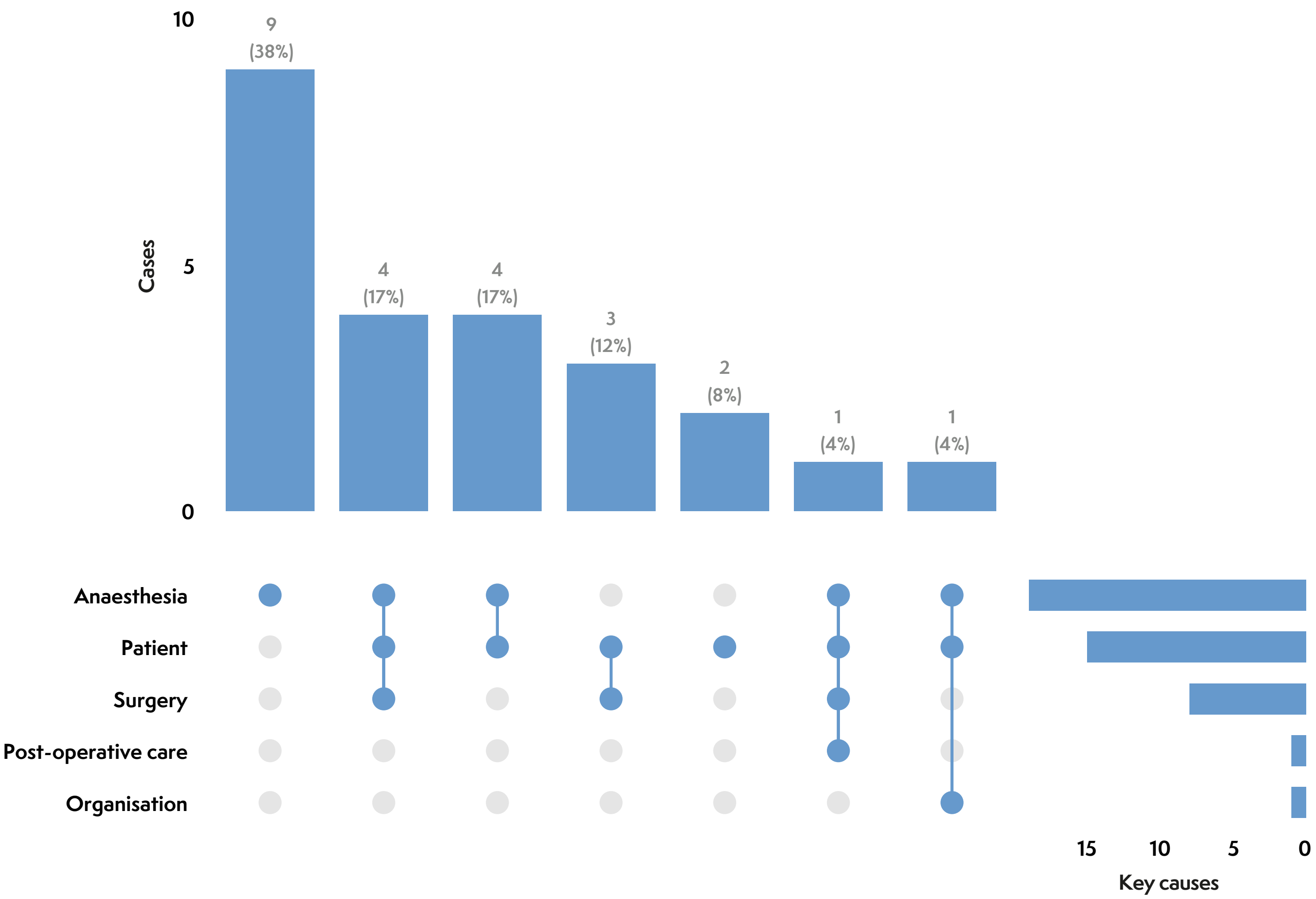


Figure 34.6 A) Obstetric patient characteristics in the NAP7 Activity Survey (purple lines) and among obstetric cases of perioperative cardiac arrest (solid blue bar). Where a blue bar is notably above or below the purple line the characteristic is over or underrepresented among patients who had a cardiac arrest, respectively. GA, general anaesthesia; RA, regional anaesthesia.

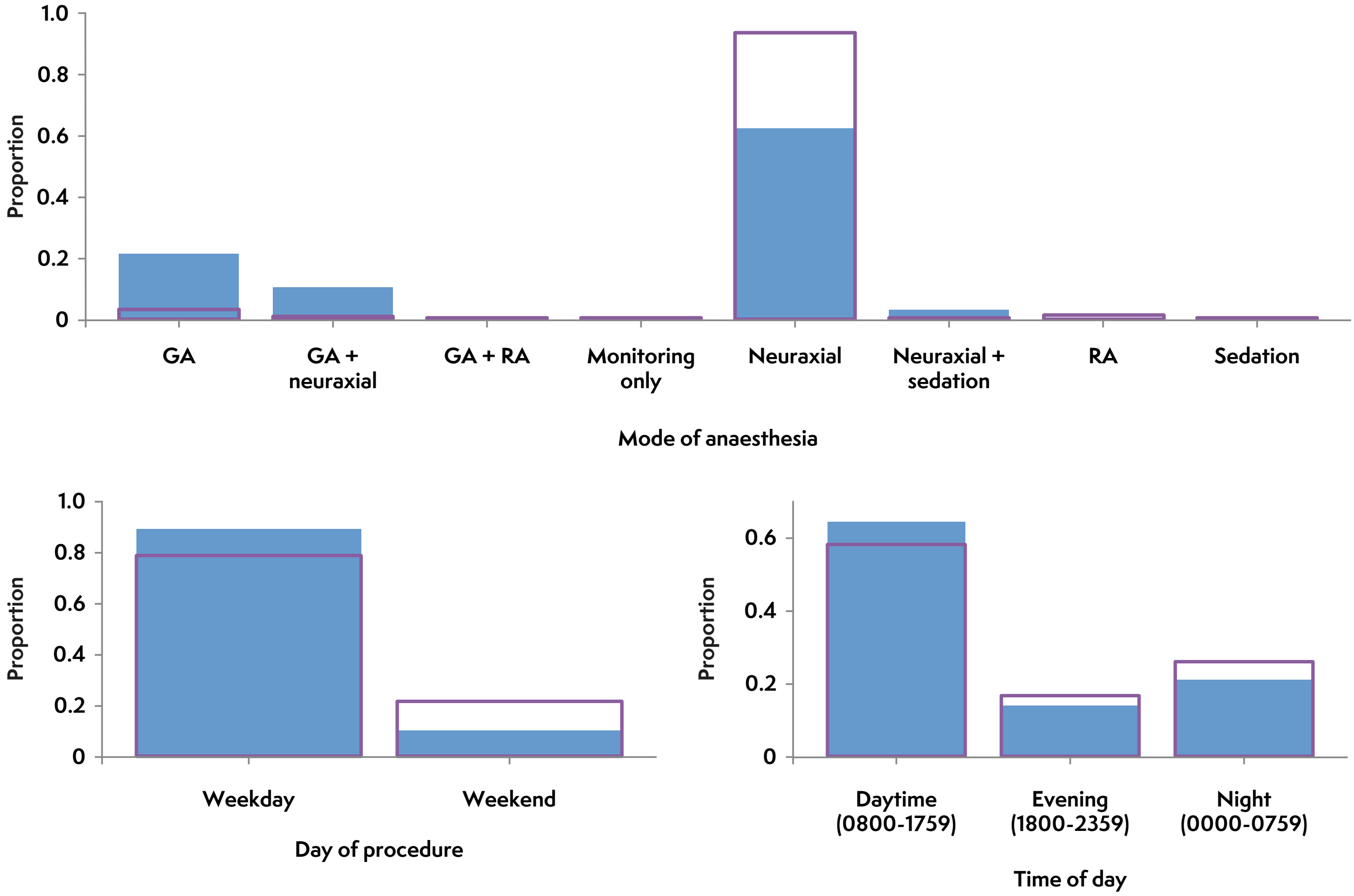
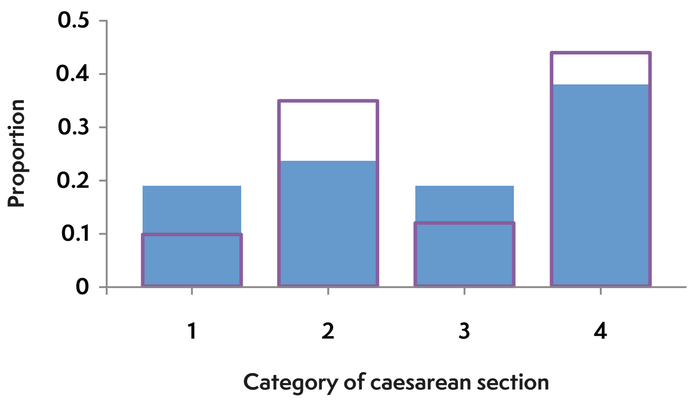


Figure 34.6 B) Category of caesarean section in the NAP7 Activity Survey (purple lines, *n*=1643) and among obstetric cases of perioperative cardiac arrest (solid blue bars, *n*=21). Caesarean section cases only; labour analgesia and other obstetric procedures excluded.



Women under 25 years were underrepresented in cardiac arrest cases, but no difference was observed across any other age groups. Among 28 women who had a cardiac arrest, 3 (11%) were ASA 3 or above compared with 6.5% of women in the Activity Survey, although the Activity Survey found that ASA scoring in obstetric patients was inconsistent.

Patients who were overweight (10 of 28, 36%) or obese (11 of 28, 39%) were overrepresented among obstetric patients having a cardiac arrest compared with obstetric patients in the Activity Survey: 866 of 3,056 (28%) were overweight and 1,018 (33%) were obese. In total, 75% of obstetric patients who arrested were overweight or obese compared with 62% of the Activity Survey obstetric population.

Obstetric patient characteristics in the Activity Survey and among cases of cardiac arrest are shown in Figure 34.6. No obstetric patient was considered frail or had a 'do not attempt CPR' recommendation.

Care

A summary of the panel's opinions regarding quality of anaesthetic care in obstetric patients who had a perioperative cardiac arrest is shown in Table 34.3. A high proportion of care during and after cardiac arrest was assessed as good, but care before cardiac arrest was less often judged to be good. For comparison, in all cardiac arrests reported to NAP7, care before cardiac arrest was judged good in 48% and poor in 11% and overall care was rated good in 53% and poor in 2%.

Of the 28 cardiac arrests in patients who received anaesthesia care, 17 occurred during daytime hours (08.00–17.59), five occurred in the evening (18.00–23.59) and five overnight (00.00–07.59), and in one case the time was not reported. A consultant was either present or attended in the majority of cases (24 of 28, 86%). There was no consultant present in three of five cases between 00.00 and 07.59.

Compared with other areas of practice, comments about the impact of the cardiac arrest on the anaesthetist were rather more frequent.

Discussion

The approximately 355,000 anaesthetic interventions estimated from our Activity Survey and approximately 695,000 live births recorded in the UK in 2021 (ONS 2023) are consistent with approximately 50% of women in the UK receiving an anaesthetic intervention during or soon after childbirth. While this is predictable activity, most anaesthetic obstetric interventions are not elective but time critical. In England, during the period of NAP7 data collections, this included approximately 15% of deliveries by elective caesarean section and 19% by emergency caesarean section (NHS Digital 2023). We report an incidence of cardiac arrest during obstetric anaesthesia interventions of around 1 in 13,000, during caesarean section of 1 in around 9,000 and during labour analgesia of 1 in around 57,000. These findings are broadly consistent with other publications (Beckett 2017, Mhyre 2014). For calculating the incidence of cardiac arrests during caesarean section, we have used the denominator from our Activity Survey (n = 188,500); if using NHS Digital (2023) data scaled up from English to UK population, which indicate 202,500 caesarean births in 2021, the incidence would fall by approximately 7%. A small number of deaths were associated with operative interventions but none with anaesthetic interventions for labour analgesia.

The changing nature of the obstetric population identified in the NAP7 Activity Survey, in particular the increase in BMI, has implications for anaesthetic care. The UK Confidential Enquiries into Maternal Deaths (CEMD) have found that women with obesity have an increased risk of death from both indirect (most notably cardiac) and direct causes (eg major obstetric haemorrhage, eclampsia and uterine rupture; van den Akker 2017). In addition, the likelihood of a woman experiencing an intrapartum intervention requiring anaesthesia (eg caesarean section) increases with BMI (Khalifa 2021). Alongside these increased obstetric risks, anaesthetic care for women with obesity is more challenging with an increased risk of complications (Patel 2021). The increased complexity of patients and possibility of intervention is likely to increase the anaesthetic workload in obstetrics. That most cases undertaken out of hours by anaesthetists are obstetric was also a finding of the NAP5 Activity Survey. Service provision for obstetric anaesthesia in the evenings and at night predominantly relies upon anaesthetists in training and SAS-grade anaesthetists. The NAP7 findings provide further evidence to support recent national recommendations that maternity units must have appropriate escalation strategies to support anaesthetists who are often more junior, working alone in the delivery suite (Ockenden 2022).

Cardiac arrest during spinal anaesthesia in any patient is a recognised complication, with an incidence previously reported to be approximately 1 in 1,000 (Pollard 2001, 2002). The mechanisms are complex and incompletely understood. In the absence of prophylaxis, spinal anaesthesia can lead to hypotension in many patients. Spinal hypotension is primarily driven by a decrease in sympathetic tone in the arterial system, leading to a decrease in systemic vascular resistance and reduced venous return because of the redistribution of blood to splanchnic and lower limb vasculatures (Salinas 2003, Carvalho 2015). A block affecting the upper thoracic spinal nerves may also block the cardioaccelerator fibres, causing bradycardia. These changes are often mild and easily reversible with vasopressors.

Spinal anaesthesia can also predispose to bradyarrhythmias that can progress to cardiac arrest. A prospective study of more than 900 non-obstetric patients reported bradycardia occurred between 12 minutes and several hours following spinal injection (Carpenter 1992). This study identified that a baseline heart rate of lower than 60 beats/minute, ASA physical status classification

Table 34.3 Quality of anaesthetic care in obstetric patients who had a perioperative cardiac arrest

Period of care	Good (n=67)	Good and poor (n=11)	Poor (n=9)	Unclear (n=22)
	n (%)	*n* (%)	*n* (%)	*n* (%)
Before cardiac arrest	10 (36)	2 (7)	5 (18)	11 (39)
During cardiac arrest	23 (85)	0 (0)	3 (11)	1 (4)
After cardiac arrest	22 (81)	2 (7)	1 (4)	2 (7)
Overall care	12 (44)	7 (26)	0 (0)	8 (30)

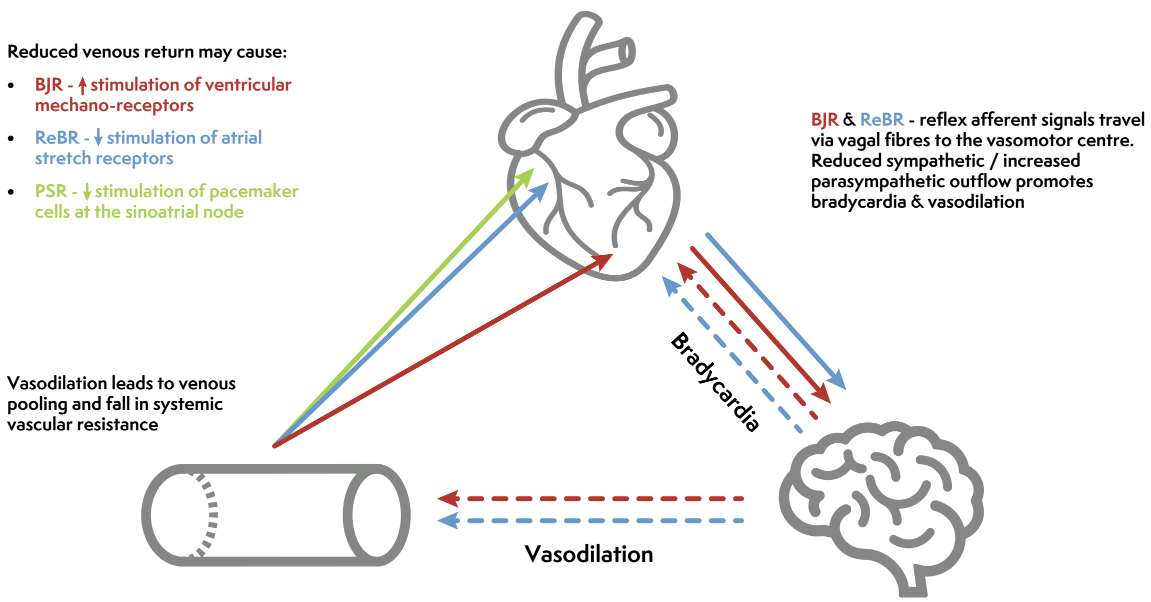
of 1 compared with 3 or 4, and peak block height greater than or equal to T5 increased the odds of developing bradycardia. Bradyarrhythmia associated with spinal anaesthesia is thought to arise due to a rapid fall in venous return affecting intrinsic cardiac reflexes (Pollard 2001, Salinas 2003, Lacey 2022). These reflexes enhance vagal tone and lead to a sudden and significant impact on cardiovascular status, including haemodynamic collapse. Three cardiac reflex mechanisms have been postulated as contributing to cardiac arrest under spinal anaesthesia: the Bezold–Jarisch, the reverse Bainbridge and the pacemaker stretch reflex.

The Bezold–Jarisch reflex is a cardioinhibitory response characterised by vasodilatation, hypotension and bradycardia (Kinsella 2001, Pollard 2001, Lacey 2022). It is initiated by activation of left ventricular-wall receptors sensitive to mechanical and chemical stimuli. When a significant reduction in venous return occurs, increased contractility of an underfilled left ventricle can stimulate myocardial mechanoreceptors and activate the Bezold–Jarisch reflex. Second, the reverse Bainbridge reflex is a bradycardic response to reduced venous return caused by the deactivation of stretch receptors in the right atrium (Crystal 2012, Lacey 2022). Third, the pacemaker stretch reflex describes the direct effect that atrial stretch has on spontaneous depolarisation of the sinoatrial pacemaker cells. A reduced venous return produces less stretch stimulation and reduces the heart rate. A schematic representation of the physiology of cardiac reflexes and their role in precipitating profound bradycardia and hypotension after spinal anaesthesia is shown in Figure 34.7.

Several additional factors may exacerbate spinal-induced bradyarrhythmia in the obstetric patient. Phenylephrine is the recommended vasopressor for prevention and treatment of spinal hypotension in obstetric patients (Kinsella 2018), but it can cause bradycardia, especially when a bolus is given or an infusion is increased rapidly, and therefore ephedrine is recommended in the presence of hypotension with bradycardia (NICE 2021). The haemodynamic effects of aortocaval compression can predispose and aggravate bradycardia and hypotension resulting from spinal anaesthesia (Murphy 2015), and this has been implicated as a factor in the UK CEMD. It may be difficult to judge whether uterine displacement has been achieved, particularly in the patient with morbid obesity. Aortocaval compression should be suspected in any supine pregnant woman who develops severe hypotension after induction of anaesthesia, even if some lateral tilt has been applied. If there is a delay in delivery, putting the woman into the left lateral position may be the only option if other manoeuvres fail or if the woman has refractory severe hypotension (Bamber 2017).

Excessive neuraxial blockade leading to cardiac arrest may also result from the unrecognised presence of a subarachnoid catheter and such a case was reported to NAP7. Local anaesthetic has an approximately ten-fold more potent effect if injected intrathecally compared to epidurally. If an epidural dose of local anaesthetic is injected into the subarachnoid space, a higher and denser neuraxial block than expected is likely. The ideal test dose to exclude intrathecal catheter placement has yet to be identified (Guay 2006). Cox investigated the effects of low concentration local anaesthetic solutions (0.1% bupivacaine

Figure 34.7 Schematic representation of the physiology of cardiac reflexes and their role in precipitating profound bradycardia and hypotension after spinal anaesthesia. BJR: Bezold–Jarisch reflex; ReBR: reverse Bainbridge reflex; PSR: pacemaker stretch reflex; ↓: decrease, ↑: increase. Reproduced with permission from Lacey 2022.



and 2 μg/ml fentanyl) given intrathecally (Cox 1995). Fifteen women undergoing elective caesarean section received 10 ml of this solution intrathecally. A spinal block with a sensory level between TI and T2 dermatomes developed over 10–15 minutes in all women. None of the patients developed respiratory depression. Two patients developed hypotension that responded rapidly to vasopressors. The authors reported that the block developed too slowly to be useful as a test dose. Nevertheless, if an epidural top-up of local anaesthetic was inadvertently given intrathecally, some sensory, motor or autonomic effects would likely be evident after a few minutes. The amount of drug in the low-dose solution used by Cox was 10 mg bupivacaine (Cox 1995), which is within the range of the ED95 of isobaric and hyperbaric bupivacaine for a caesarean section (Ginosar 2004, Carvalho 2005). Therefore, 10 mg bupivacaine (or equivalent) may allow the recognition of an unintended intrathecal catheter while minimising the risk of a high neuraxial block; it should be sufficient to have some clinically evident sensory, motor or autonomic effect but unlikely to lead to a block height associated with cardiorespiratory compromise. In the cases of high spinal block in NAP7, notably higher doses than 10 mg bupivacaine were administered.

A high neuraxial block may also develop in association with a spinal anaesthetic administered after an epidural 'top-up' (eg when labour epidural analgesia is topped-up in a patient who requires an emergency caesarean section) but the block is inadequate for surgery. When a spinal and epidural are undertaken together (either as a specific technique, 'combined spinal–epidural' or sequentially as part of a rescue approach for an inadequate block), it is essential to recognise that the effect of the two may be synergistic, affecting block characteristics such as speed of onset and height of the block. When fluid (top-up solution) is already in the epidural space, the dural sac will be compressed, resulting in a higher block with a subsequent spinal (Higuchi 2005, Stocks 2005). This mechanism is likely to be related to variability in the compliance of the epidural and subarachnoid spaces in individuals and makes picking a suitable dose for a repeat neuraxial technique challenging.

It is perhaps not surprising that anaesthetic factors (high neuraxial block and bradyarrhythmia) were the leading cause of perioperative cardiac arrest in obstetric patients. This is in contrast to other areas of anaesthesia practice (e.g. vascular anaesthesia) where patient factors related to co-morbidities predominate. Obstetric patients are generally younger and fitter with healthy and responsive cardiovascular systems. They may be more susceptible to brisk cardiac reflexes that can precipitate cardiac arrest, particularly in the presence of inadequately relieved aortocaval compression. This should not necessarily be seen as substandard anaesthetic practice. Nevertheless, it behoves anaesthetists practising obstetric anaesthesia to be mindful and vigilant to the risks associated with spinal anaesthesia, particularly in situations that may result in high neuraxial blocks or require conversion of neuraxial anaesthesia to general anaesthesia.

Notably, haemorrhage was the single leading cause of perioperative cardiac arrest in obstetric patients in NAP7. Although obstetric haemorrhage can be precipitous and easily recognised, this is not always the case, with significant blood loss accruing gradually in many cases. Obstetric patients generally have robust cardiovascular systems that compensate remarkably well, even in the presence of significant hypovolaemia. This can lead to the extent of bleeding being underestimated and inadequate resuscitation. These observations reinforce critical areas for improvement in managing obstetric haemorrhage identified by the UK CEMD (Bamber 2020b). It is essential that in the perioperative setting, where the detrimental cardiovascular effects of anaesthesia and haemorrhage can combine to cause collapse, the severity of haemorrhage is recognised and communicated. For example when a woman is being transferred to theatre for management of postpartum haemorrhage, the extent of blood loss must be communicated to the midwifery, anaesthetic and obstetric teams. Strategies to increase accuracy of blood loss assessment include avoiding false reassurance from haemoglobin estimations, eg caused by using point-of-care devices before the circulating volume has been restored. A haemoglobin concentration without adequate fluid resuscitation will not reflect the magnitude of the haemorrhage or the need for transfusion.

Induction agents can cause haemodynamic compromise and a hypovolaemic patient will be more vulnerable to the hypotensive effects of anaesthesia. While clinicians may intuitively reduce induction agent doses when anaesthetising a patient with haemorrhage, this increases the risk of awareness during anaesthesia. This underlines the necessity for adequate resuscitation before anaesthetic induction, with rapid recourse to vasopressors if hypotension develops. Alternative induction agents associated with greater haemodynamic stability, such as ketamine, may be preferable when surgical intervention cannot wait (Morris 2009).

Consistent with findings related to obstetric patients in NAP4 and NAP5, NAP7 identified that conversion of a neuraxial anaesthetic to general anaesthesia was associated with an increased risk of complications. These situations must be recognised as a time of increased risk for airway complications, accidental awareness and cardiac arrest, and one in which senior staff should be involved.

In several cases, the cause of the cardiac arrest was attributed to anaphylaxis, despite limited clinical evidence and subsequent negative serum tryptase. In several, the NAP7 panel disagreed with a reporter's proposed diagnosis of anaphylaxis. NAP6 found that anaphylaxis was less frequent in the obstetric perioperative compared with the general population. While anaphylaxis should always be a differential diagnosis in the presence of sudden perioperative collapse, other more common causes must be excluded.

There were no cases of cardiac arrest associated with local anaesthetic toxicity or remifentanil PCA. However, the finding regarding remifentanil PCA must be interpreted with significant

caution. The Activity Survey did not collect data on use of remifentanil PCA. The technique is currently not widely used. The consensus is that continuous one-to-one midwifery care is essential to support the safe use of remifentanil PCA (Muchatuta 2013). Recently, there have been reports of obstetric units being unable to provide this mode of analgesia because of midwifery staff constraints. In draft guidance published for consultation in April 2023, the National Institute for Health and Care Excellence guideline on intrapartum care for healthy women and babies recommends that the risks and benefits of remifentanil PCA should be discussed with women (NICE 2023).

Consistent with other reports, we have found an excess of cardiac arrest in obstetric patients of Black ethnicity (Guglielminotti 2021). The numbers in this report are small and therefore the result somewhat 'fragile' but it is notable, nonetheless. Ethnic and socioeconomic inequalities are associated with adverse pregnancy outcomes and there is a higher risk of maternal death for women from Black and Asian ethnic minorities in the UK (Knight 2020). A 2023 study investigating the effect of ethnicity on obstetric anaesthesia care in England identified disparities in the provision of anaesthesia and analgesia for labour and delivery (Bamber 2023). For elective caesarean section, women from Black Caribbean and Black African groups had a 30–60% higher incidence of being given general anaesthesia than White British women. Black Caribbean women also had a 10% higher incidence of receiving general anaesthesia for emergency caesarean section. For women who had unassisted vaginal births, Bangladeshi, Pakistani and Caribbean women had a 24%, 15% and 8% lower incidence, respectively, of having had a spinal or epidural compared to White British women. These findings are of direct relevance when seeking to improve maternal outcomes, including cardiac arrest. Avoidable general anaesthesia for caesarean section is associated with an increased risk of adverse maternal outcomes, including cardiac arrest (Guglielminotti 2019). Epidural analgesia in labour is associated with a reduced risk of morbidity outcomes, particularly obstetric haemorrhage (Guglielminotti 2022). Ethnicity and perioperative cardiac arrest are discussed further in Chapter 30 Ethnicity.

Finally, the Activity Survey identified that a high proportion of obstetric patients were assigned an incorrect ASA class. It was not until 2020 that specific examples of use of ASA classification in obstetric (and paediatric) patients were included. Although identifying high-risk patients is obviously essential, there is no evidence to date that use of the ASA classification in the obstetric population is appropriate. Equating the physiological changes in pregnancy with mild systemic disease (ASA 2) is controversial.

The overall findings of NAP7 are reassuring, with obstetric care being associated with a low risk of cardiac arrest (four-fold lower than other specialities) and high survival rates when cardiac arrest occurs. This is despite much obstetric care being undertaken as urgent or emergency care, throughout the night, often by non-consultant staff and in remote locations. There is much to be positive about in the NAP7 report regarding obstetric care but, notwithstanding this, episodes of cardiac arrest do occur. We make several recommendations to raise awareness around the causes of perioperative cardiac arrest in obstetric patients and improve care.

Recommendations

National

- Staffing models for obstetric anaesthesia should reflect the distribution of clinical activity, particularly the greater burden of workload overnight compared to other areas of anaesthetic practice to ensure that the staff levels are safe for patient care.

Institutional

- Anaesthetic departments should have appropriate escalation strategies in place to support more junior anaesthetists caring for patients with comorbidity in an obstetric setting (eg an elevated BMI) and to facilitate rapid support in the event of a critical emergency.
- A consultant anaesthetist should attend as soon as possible to support clinical management of an obstetric patient who has had a cardiac arrest.

Individual

- Anaesthetists should anticipate and be prepared to treat bradyarrhythmias during spinal anaesthesia, particularly when phenylephrine is used.
- For obstetric patients with spinal anaesthesia, inadequate relief of vena caval compression should be considered and managed as a contributing cause of bradyarrhythmias and tachyarrhythmias.
- For labour epidural analgesia, a test dose of local anaesthetic solution should not exceed the equivalent of 10 mg bupivacaine (eg 10 ml 0.1% bupivacaine and 2 μg/ml fentanyl or equivalent local anaesthetic).
- When undertaking a second neuraxial technique following the failure of the primary neuraxial anaesthetic, the risk of a high neuraxial block must be considered. Strategies should be used to modify the risk (eg a reduced dose of local anaesthetic or titration of doses of local anaesthetic or adjustments to the patient's position).
- When undertaking general anaesthesia on a background of obstetric haemorrhage, the patient should be adequately and promptly resuscitated. Vasopressors may be required to treat a hypotensive response to induction of general anaesthesia but should not be used as a substitute for adequate intravascular fluid replacement. This is particularly relevant in patients where anaesthesia is being converted from neuraxial to general.

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