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## NAP7 headlines and summary of key findings



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### Headlines

1. In the last decade, the population of patients cared for by anaesthetists has increased in age (approximately 2.3 years), comorbidity (the proportion of healthy ASA 1 patients has fallen from 37% to 24%) and in both the prevalence of obesity (overweight or obese patients rising from 49% to 59%) and its extent (a 7.2% increase in severe obesity). These changes significantly increase the risks for patients of undergoing anaesthesia, and impact anaesthesia workload across the entire perioperative pathway.
2. Our survey of overall anaesthetic activity included more than 24,000 patients' care and identified potentially serious complications in 1 in 18 anaesthetics. Around one-third of these were cardiovascular in nature, and a quarter were related to the airway. Complications occurred disproportionately in urgent or emergency surgery in high-risk settings. Complications were more common in the very young and older patients. Complications were also associated with patient comorbidity (ASA grade), male sex, increased frailty, the urgency, duration and complexity of surgery, and out-of-hours procedures. The vast majority of complications were managed effectively by the anaesthesia team.
3. Our registry included 881 reports of perioperative cardiac arrest with an overall incidence of approximately 1 in 3,000 anaesthetics.
4. Three-quarters of patients survived the initial event, and 60% were alive when the case was reported to NAP7, with 44% having been discharged from hospital. These survival rates are notably higher than other in-hospital cardiac arrests – 49.5% surviving the event and 23% leaving the hospital alive. Of those surviving to hospital discharge, 88% had a favourable functional outcome.
5. The most common causes of perioperative cardiac arrest were major haemorrhage (17%), bradyarrhythmia (9.4%) and cardiac ischaemia (7.3%) but varied by surgical specialty. Anaphylaxis was likely overestimated as a cause of cardiac arrest in our survey of anaesthetists and in reported cases, with many of these cases judged by the NAP7 panel to have other causes.
6. The initial rhythm during perioperative cardiac arrest was non-shockable in 82%, and only 17% required defibrillation. Bradycardic cardiac arrest had the highest rate of successful resuscitation and survival to hospital discharge at the time of reporting to NAP7 (86% and 60%), and pulseless electrical activity the lowest (68% and 34%).
7. Patient factors were a key cause in 82% of cases of perioperative cardiac arrest, anaesthesia in 40% and surgery in 35%. In 31% of fatalities, death was judged to be due to an inexorable process.
8. Cardiac arrest was usually well managed. A senior anaesthetist was present at induction of 97% of cases reported to NAP7, including a consultant present at induction in 86% and at the time of cardiac arrest in 73%.

## Key findings

- Resuscitation was prompt, and help was called for and attended rapidly. Adrenaline was administered in 79% of cases, and other drugs in 38%. Relative overdosing of adrenaline occurred in a small number of cases when lower doses might have been used, and in a small number of cases caused complications. No complications of low-dose intravenous adrenaline were seen during anaphylaxis treatment. Calcium (13% of cases) and bicarbonate (7.2%) were administered frequently and sometimes without clear indication, notably in children and postoperatively in critical care.
9. Perioperative cardiac arrest was more common in older-frailer patients (1 in 5 cardiac arrests with an incidence of 1 in 1,200), and in high-risk and urgent or emergency surgery.
  10. Patient groups with better than average outcomes included children (but not those awaiting transfer to a tertiary centre), cardiac surgery patients and cardiac arrest due to suspected anaphylaxis or airway complications. Poorer outcomes occurred in vascular surgery, cardiology, radiology, in frailer and older patients, in cases due to major haemorrhage, in obese patients with a body mass index (BMI) > 40 kg m<sup>-2</sup>, and in critically ill children awaiting transfer to tertiary care.
  11. Perioperative cardiac arrest or death in low-risk patients was very rare. Among patients without significant comorbidity (ASA 1-2) peri-operative cardiac arrest occurred in around 1 in 8,000 cases and fewer than 1 in 100,000 died.
  12. The highest prevalence specialties for perioperative cardiac arrest were orthopaedic trauma, lower gastrointestinal, cardiac, vascular surgery and interventional cardiology. The most overrepresented were cardiac surgery, cardiology, vascular and general surgery, with obstetrics underrepresented.
  13. Despite many of the patients reported to NAP7 being very high risk patients, only 6.1% had a do-not attempt cardiopulmonary resuscitation (DNACPR) recommendation made preoperatively. DNACPR recommendations were documented in only 24% of cases with documented frailty, with 15% having treatment limitations. Most DNACPR recommendations were not suspended during surgery, and 1 in 5 of those with a DNACPR recommendation who had a cardiac arrest and CPR survived to leave hospital.
  14. There were six cases of unrecognised oesophageal intubation in NAP7. Conversely rates of emergency front of neck airway and pulmonary aspiration appeared notably lower than in previous large studies, including NAP4.
  15. While care was judged good far more often than poor (76% vs 4.7% of assessments), there are opportunities for improvement, especially in the prevention of cardiac arrest, with elements of poor care before cardiac arrest identified in 32% of cases.
    - a. 71% of adult perioperative cardiac arrest cases did not have evidence of pre-operative risk scoring and NAP7 demonstrated that risk tools used to predict short term mortality (eg SORT) have good utility for stratifying risk of perioperative cardiac arrest.
    - b. While supervision of trainees by senior anaesthetists was almost universal, access to senior support was occasionally judged inadequate when anaesthesia was delivered in isolated locations.
    - c. National guidelines for monitoring during anaesthesia were not followed in a significant number of cases. This reduces the opportunity to recognise early deterioration. Monitoring was notably deficient during transfer of patients to recovery areas and NAP7 included cases where this contributed to cardiac arrest.
    - d. Drug choice and/or dosing was judged to have contributed to a substantial proportion of perioperative cardiac arrests. This occurred more commonly in patients who were older and frailer, with higher ASA grade or acute illness and perhaps with propofol and remifentanyl based total intravenous anaesthesia (TIVA). Lower doses, slower induction, use of vasopressors and sometimes different drug choices may have prevented some cardiac arrests.
    - e. In some patients who were anaesthetised in the anaesthetic room the review panel judged anaesthesia in theatre would have been safer. Also, in cases in which the anaesthetic room was used for induction and cardiac arrest occurred before surgery started, the panel judged anaesthesia to be a key cause of cardiac arrest more commonly and care before cardiac arrest to be poor more often and good less often than in other cases.
  16. NAP7 did not receive sufficient engagement and responses from the independent sector (which in addition to externally funded care, provides around one in six NHS-funded perioperative care episodes, a proportion which is increasing) and as such has insufficient data to enable us to determine whether perioperative care in that setting is more, equally or less safe than in the NHS. This is a matter of concern.

17. Training of anaesthetists and provision of equipment for managing perioperative cardiac arrest is generally well implemented in NHS hospitals but is incomplete. It is notably less complete for anaesthesia care in children and for anaesthesia delivered in remote locations.
18. Among the over 10,000 anaesthetists responding to our national survey, almost half had been involved in managing at least one perioperative cardiac arrest in the previous two years (7% a child and 4% a pregnant woman) and 85% over the course of their career. Anaesthetists were confident in managing these events but less so in managing the aftermath or communicating with next of kin.
19. There is a potential for unrecognised impact on the staff involved in the management of perioperative cardiac arrest, which may influence future staff wellbeing and patient care. Among around 5,000 anaesthetists who had attended a recent perioperative cardiac arrest 4.5% reported that this had had an impact on their subsequent ability to deliver patient care. This was more common when the cardiac arrest involved a child, an obstetric patient or an unexpected death. In the case registry 3.4% of anaesthetists reported the same and 5.2% declined to answer this question. Formal psychological support for staff after managing cardiac arrests was uncommonly available or accessed. Anaesthetists reported that recent involvement in management of perioperative cardiac arrests most commonly led to negative psychological impacts, while career involvement led most often to positive professional impacts (in one in three anaesthetists) and negative impacts on professional life (in one in four anaesthetists).
20. Comparing these data to previous NAPs – specifically NAP4 which reported on airway complications and NAP6 on anaphylaxis – suggests improvements in the quality of care and patient outcomes over the last decade, despite the increasing challenges of the modern patient population.

## Summary of key findings

NAP7 covers a very wide range of anaesthetic practice and complications. These are described in detail in the individual chapters. In this regard NAP7 is perhaps more wide-ranging than previous NAPs. We have summarised some of the key findings below.

The **surgical population** – specifically the approximately 3 million patients receiving anaesthesia each year - has over the last decade, become older, more obese and more comorbid. The average age of patients has risen 2.3 years, the proportion of patients who are fit and well (ASA 1) has fallen from 37% to 24% and those with more severe comorbidity (ASA 3 or 4) risen from 21% to 29% and the average BMI has risen from 24.9 kg m<sup>-2</sup> to

26.7 kg m<sup>-2</sup> with 69% of patients now overweight or obese. The population now undergoing anaesthesia is at notably higher risk of complications than it was a decade ago.

**Potentially serious complications** occur during anaesthesia in 1 in 18 cases (6%). Circulatory events accounted for most complications (36%), followed by airway (24%), metabolic (15%), breathing (15%), 'other' (6%) and neurological (2%) events. Most complications reported occurred in high-risk settings such as urgent and immediate priority surgery. Complications were associated with very young or older age, higher ASA, male sex, increased frailty, the urgency and extent of surgery.

Approximately half of the more than 10,000 anaesthetists responding to the Baseline Survey had been involved in managing at least one cardiac arrest in the previous two years (7% a child and 4% an obstetric patient) and 85% in their career.

NAP7 included **881 reports** of perioperative cardiac arrest, an estimated incidence of 1 in 3,000 anaesthetics. Of the 881 reports, 88% were in adults (3% obstetric) and 12% children, 56% were male, median age was 60.5 years; 74% were ASA 3-5 and 60% were having major or complex surgery. There was a bimodal age distribution with overrepresentation of infants and adults aged over 65 years. Cardiac arrests were associated with increased age, comorbidity, frailty, male sex, urgent and emergency surgery, weekends and out of hours. Patient factors were a key cause in 82% of cases, anaesthesia in 40% and surgery in 35%.

**Highest prevalence** specialties were orthopaedic trauma, lower gastrointestinal, cardiac, vascular surgery and interventional cardiology. The **most overrepresented** were cardiac surgery, cardiology, vascular and general surgery, with obstetrics underrepresented. During elective surgery the commonest non-cardiac specialties were gynaecology, urology and orthopaedics, and during non-elective cases orthopaedic trauma, lower gastrointestinal and vascular surgery. Bleeding, emergency laparotomy and ruptured abdominal aortic aneurysm were all important causes of cardiac arrest. Cause of cardiac arrest varied notably with surgical specialty. For cardiac-related specialties the commonest cause was cardiac ischaemia, for upper and lower gastrointestinal surgery it was septic shock, for ENT it was hypoxaemia and for pelvic specialties it was bradyarrhythmia. These data highlight the specialty-specific nature of major complications that lead to cardiac arrest – likely a complex interaction of patient, surgical and anaesthetic factors. Haemorrhage, despite being the commonest cause only in vascular surgery, was the commonest cause across all specialties, most likely as it ranked highly as a cause in most specialties.

While most perioperative cardiac arrests occurred in theatres in hours, 26% were before surgery started, 17% occurred after leaving recovery, 12% occurred in critical care, and 38% were out of hours.

**Risk analysis** of the Activity Survey and perioperative cardiac arrest cases reported to NAP7 showed:

- a. Objective estimates of 30 day mortality strongly predict risk of cardiac arrest. Compared with lowest risk (< 1% predicted risk of early mortality), patients with predicted low (1–5%), high (5–10%) and very high (> 10%) risk had a relative risk of perioperative cardiac arrest of 5.2, 13.3 and 40.9, respectively.
- b. Risk of perioperative cardiac arrest rises with increasing risk using the Surgical Outcome Risk Tool (SORT):
  - SORT risk <1%, risk of cardiac arrest 1 in 7,000
  - SORT risk 5-10%, risk of cardiac arrest 1 in 1,300
  - SORT risk >10%, risk of cardiac arrest 1 in 170.
- c. ASA-physical status was under-scored in both the Activity Survey and case reviews.
- d. 71% of adult perioperative cardiac arrest cases lacked pre-operative risk scoring. This was particularly prevalent in highly frail patients.
- e. Gaps were highlighted in the preoperative assessment of high-risk patients, regarding choice of face-to-face or remote assessment, and nurse- or anaesthetist-led assessment.

The **senior anaesthetist** at induction was a consultant in 86% of all cases, including 75% at night. A senior anaesthetist was present at the time of cardiac arrest in 73% cases, with further anaesthetists called in 63% and usually arriving within 1 minute.

In the Baseline Survey, anaesthetists estimated the three **most common causes** of perioperative cardiac arrest to be hypovolaemia, hypoxaemia and cardiac ischaemia or failure, with haemorrhage fifth. Conversely the commonest causes of the cardiac arrest most recently attended by respondents were major haemorrhage (20%), anaphylaxis (10%) and cardiac ischaemia (9%). In cases reported to NAP7 the most common causes were major haemorrhage (17%), bradyarrhythmia (9.4%) and cardiac ischaemia (7.3%) varying by surgical specialty. Anaphylaxis was the seventh (4%) leading cause.

**Pulseless electrical activity** (PEA) was the most common initial cardiac arrest rhythm and 82% of cases presented with a non-shockable rhythm. Adrenaline was used in 79% of reported cases and other drugs in 38%.

Most (65%) cases of PEA or severe bradycardia received an initial 1 mg dose of **adrenaline**. Several complications of high-dose adrenaline were seen when a smaller dose might have been effective. Underdosing of adrenaline was seen only rarely. There were several cases of significant delay in administration of adrenaline. Calcium use was documented in 13% of NAP7 cases and bicarbonate use in 7.2% (particularly in children and in intensive care units) with much of this use without a clear indication. Resuscitation started within 1 minute in 78% of

cases. Despite anaesthetists generally indicating they would start resuscitation in comorbid patients when blood pressure fell below 50mmHg, delay in starting chest compressions when blood pressure was very low or even unrecordable was relatively common. Most resuscitation attempts (67%) lasted for less than 10 minutes and 3.7% for more than 1 hour.

Severe **bradycardia** (<30/min) was reported in 1 in 450 cases in the Activity Survey. Progression to bradycardic cardiac arrest was rare ( $\approx$  1 in 50,000). Laparoscopy for gynaecology was high risk for bradycardia (1 in 180 cases) with bradyarrhythmias requiring chest compressions occurring in 1 in 4,500 cases, all of whom survived. **Bradyarrhythmia** was also a common form of cardiac arrest in NAP7 cases: 74% survived to hospital discharge compared with 37% for all other reported cases. **Tachyarrhythmias** (new-onset atrial fibrillation (AF), rapid AF, ventricular tachycardia or supraventricular tachycardia) were approximately three-fold less common (1 in 550 cases) than bradyarrhythmias, with cardiac arrest occurring in 1 in 50,000 cases.

Most patients (75%) who have a perioperative cardiac arrest **survive** the initial resuscitation and achieve a sustained return of spontaneous circulation (ROSC). At the time of reporting to NAP7 60% of patients were alive and 44% had survived and been discharged from hospital. Most (88%) of those surviving to hospital discharge had a favourable functional outcome.

In the Activity Survey 2.9% of patients had a '**do not attempt cardiopulmonary resuscitation**' (DNACPR) recommendation and this was suspended during anaesthesia in fewer than one-third of cases. Among cases reported to NAP7 6.1% of cases had a DNACPR recommendation. Of these, 70% were frail and the recommendations were formally suspended in just under half of cases.

In panel judgements of **quality of care**, this was rated good in 53%, good and poor in 28%, poor in 2% and unclear in 17%. Elements of poor care before the cardiac arrest were identified in 32% of cases but care after cardiac arrest was rated good in 80% of cases. Thirty one percent of deaths were judged to be the result of an inexorable process.

In the **independent sector**, despite considerable effort, the project did not receive the engagement or data that it received from the NHS, likely receiving around 10% of desired data. This precluded some analysis. Compared with the NHS, the independent sector caseload is less comorbid, with fewer patients at the extremes of age severely obese or frail. Much activity is elective orthopaedic surgery, undertaken during weekday working hours. Cases reported from the independent sector (eg following haemorrhage, anaphylaxis, cardiac arrhythmia and pulmonary embolus) clearly illustrate that life-threatening emergencies can and do occur there. Outcomes were similar to the NHS, though given the case mix better outcomes might be anticipated. Reported care was variable and overall quality of perioperative cardiac arrest care was assessed as good less often than in NHS cases, but many assessments

were uncertain reflecting poor quality reports. Overall NAP7 has not received sufficient data returns from the independent sector to enable us to determine whether perioperative care in that setting is more, equally or less safe than in the NHS.

**Drug choice and/or dosing** was judged to have contributed to a substantial proportion of perioperative cardiac arrest cases, especially in patients who were elderly and/or frail, with higher ASA grades or acute illness. Use of vasopressors around induction may have prevented some arrests. Excessive or too rapid dosing at induction (including during TIVA with propofol and/or remifentanyl, and during intrathecal anaesthesia) was judged to have contributed to several cases of cardiac arrest.

**Older and frailer patients** were prominent throughout NAP7. Older patients (> 65, > 75 and > 85 years) accounted for 27%, 13% and 3.1% of Activity Survey caseload, respectively and 26% of patients over 65 years were reported to be frail (ie clinical frailty scale (CFS) score  $\geq 5$ ). Increasing age and frailty were both associated with more comorbidities, undergoing more urgent or emergency surgery, an increased proportion of complex or major surgery and more complications (8.5% in frail patients vs 5.2% in non-frail). Although monitoring intensity generally increased as frailty increased this was not sustained in the severely frail (CFS 7 and 8). Older-frailer patients ( $\geq 65$  years and CFS  $\geq 5$ ) accounted for 1 in 5 adult reports to NAP7. Incidence of cardiac arrest was around 1 in 1,200 and of death 1 in 2,000 (or 4.8 per 10,000). Incidences in all patients over 85 years and all patients with CFS 7–8 were very similar to these. Hip fracture, emergency laparotomy and emergency vascular surgery were the most common surgical specialties. Cardiac arrest rhythm was non-shockable in 92% of cases. Mortality was higher than in non older-frailer patients (at cardiac arrest 35% vs 21% and at the time of reporting 60% vs 35%), though only 19% were judged due to an inexorable process. DNACPR recommendations were documented in 24% of cases, with most not suspended during surgery. Care before cardiac arrest was judged poor or good and poor in the majority of cases, and generally good during and after the arrest.

**Vascular surgery** was a high impact specialty in NAP7 accounting for 1.7% of Activity Survey caseload and 7.8% of cases reported to NAP7 (four-fold overrepresented) with an incidence of perioperative cardiac arrest of 1 in 670. Outcomes in the vascular population were also notably poor: 70% had died at the time of NAP7 reporting with 16% still admitted. The vascular surgical population is high risk (43% ASA 4, 28% ASA 5, 80% older than 65 years, with 82% of vascular surgery cardiac arrests occurring during non-elective surgery). The most common procedures in vascular cases were aortic surgery (55%), lower-limb revascularisation (19%) and lower-limb amputation (12%). The highest risk and poorest outcomes occurred in emergency surgery for ruptured abdominal aortic aneurysm, where the incidence of perioperative cardiac arrest was around 5% (6.6% for open repair and 2.4% in endovascular repair). The

most common cause of cardiac arrest was major haemorrhage (40%) but with multiple other causes reflecting the critical illness of the patients and the complexity of surgery.

About 40% of arrests occurred during surgery, but many also at or soon after induction. In some cases, surgery was judged futile and inappropriate. Patient factors were a key cause in 88% of cases, followed by anaesthesia (33%) and surgical factors (30%). Care before cardiac arrest was judged good in 46% of cases and during and after cardiac arrest in around 80%.

**Major haemorrhage** occurred in 1% of all Activity Survey cases and was the primary or major contributory cause of cardiac arrest in 19% of NAP7 cases, being notably overrepresented. The incidence of cardiac arrest from major haemorrhage was 0.62 per 10,000. It was a major cause in 10% of cardiac arrests in elective cases and 22% in non-elective cases. Mortality was relatively high: 35% did not achieve ROSC (vs 21% in other cardiac arrests) and 56% died before reporting to NAP7 (vs 36%). In 52% of these cases this was judged the result of an inexorable process. Cardiac arrest from major haemorrhage occurred most commonly in adults (92%) and during immediate urgency surgery (57% compared with 19% among all NAP7 cases) but 17% of cases involved elective surgery. The commonest specialties were vascular surgery (27% of major haemorrhage cases) and gastroenterology/gastrointestinal surgery (22%) with relatively few (8.4% of major haemorrhage cases, 1.6% of all NAP7 cases) associated with major trauma. Seven percent of cardiac arrests from major haemorrhage occurred during minor procedures, mostly endoscopy. Patient factors were a key cause in 84% of cases, surgery and anaesthesia in 16%. The cardiac arrest rhythm was non-shockable in 85% of cases. Care was judged to be good in 84% of cases during and after cardiac arrest, but in only 53% before cardiac arrest.

**Airway management** remains a prominent cause of cardiac arrest, accounting for 1 in 7 cases and 9.2% of deaths reported to NAP7. In the Activity Survey airway complications were the second most frequent complication (incidence 1.7%, 22% of all complications) with laryngospasm (38%) and airway failure (30%) prominent, while breathing complications were fourth (1.1% of cases, 14% of all complications). High risk patient groups were infants and critically ill children, the obese, patients undergoing head and neck surgery and those cared for out of hours. The Activity Survey showed that compared to NAP4, there were slightly increased rates of tracheal intubation, notably more use of second generation supraglottic airways, reduced rates of pulmonary aspiration and of cannot intubate, cannot oxygenate (CICO)/emergency front of neck airway (eFONA) (Activity Survey 1 in 8,370, 6 cases in reports to NAP7). There were six cases of unrecognised oesophageal intubation reported to NAP7. Cautiously, the data, while distinct from NAP4, suggest that airway management is likely to have become safer in the last decade, despite the surgical population having become more anaesthetically challenging.

In the Baseline and Activity Surveys there was evidence of less preparedness for **paediatric** cardiac arrest than for adults. Availability of paediatric advanced airway equipment and defibrillators was lower than for adult practice and training in paediatric advanced life support (ALS) was lower than in adult ALS. Of the 165 hospitals caring for children, 87% do not have a paediatric intensive care unit (PICU) on site and so require systems in place to stabilise critically ill children before retrieval to a specialist children's hospital. Paediatric anaesthesia accounted for 14% of anaesthesia caseload and 12% of all submitted reports, cardiac arrest being most common in neonates (1 in 200), infants (1 in 500) and children with congenital heart disease. Frequent precipitants included severe hypoxaemia, bradycardia and major haemorrhage (all settings) and cardiac tamponade and isolated severe hypotension in cardiac settings. Outcomes were better than adults with initial ROSC 83% vs 74%, and survival at the time of reporting to NAP7 (74% vs 60%). Supervision of trainees by senior anaesthetists was almost universal but access to senior support was occasionally judged inadequate when anaesthesia was delivered in isolated locations. There were cases in which risk was so high that the presence of two consultants would likely represent best practice. A debrief followed paediatric cardiac arrest twice as often when the child died (78%) as when they survived (35%). In several cases of unwell children who had a cardiac arrest inappropriate choices and doses of drug for intravenous induction and high concentrations of volatile anaesthetic for induction or maintenance precipitated severe hypotension and cardiac arrest. Other themes included bradycardia during airway manipulation, tracheal tube displacement in the intensive care and delayed recognition of deterioration including due to inadequate monitoring such as the lack of invasive arterial monitoring in cardiac catheterisation cases.

**Cardiac arrest in critically ill infants and children requiring resuscitation and stabilisation by district general hospital staff** before transfer to a regional paediatric intensive care unit was an uncommon event, occurring every 1 in 160 cases, with 13 cases reported to NAP7. Patients in this group were older than in the general paediatric cohort (eg seven patients were 6–15 years). Stabilisation and anaesthesia was usually out of hours and was undertaken in multiple hospital locations. Senior anaesthetists were present for all cases, but most did not have regular paediatric anaesthetic sessions. Hypoxaemia and airway complications (often composite) were the most frequent causes of cardiac arrest. Key contributory factors were the patient in 75% and anaesthesia in 25%. Mortality was high – 5 of 13 children died. In addition, long-term physical and mental health impacts on staff involved in cardiac arrest management were reported.

Anaesthetists likely identify **anaphylaxis** as a cause of cardiac arrest more commonly than it occurs and only half of cases reported to the NAP7 as anaphylaxis were considered to be so by the review panel. Grade 4 perioperative anaphylaxis was managed initially with low-dose intravenous adrenaline most

often and this was without complications. Delay in starting chest compressions when systolic blood pressure was <50 mmHg or even unrecordable occurred too often. Grade 4 anaphylaxis occurred with a similar frequency and patterns of presentation, location, initial rhythm and suspected triggers in NAP7 as in NAP6. Outcomes in NAP7 were generally better than in NAP6. There was only one death and 97% survived. Care was judged good more often in NAP7 than it had been in NAP6, and poor less often than it had been in NAP6.

**Cardiac surgery** accounted for 0.9% of anaesthesia caseload in the Activity Survey. The 50 cardiac arrests (likely to be an underestimate through underreporting) related to cardiac surgery, accounted for 5.7% of NAP7 cases and an incidence of 1 per 400 cardiac surgical cases. A high proportion (80%) were initially successfully resuscitated, and at the time of reporting to NAP7, 48% were alive and had been discharged, 22% were still hospitalised and 30% had died. Cardiac surgery cardiac arrests were twice as likely to be postoperative than other NAP7 cases (58%). Peaks were seen at weekends/public holidays (4-fold increase) and between 00:00–03:00 and 15:00–18:00. A consultant or post-CCT doctor was present at 82% of cardiac arrests (daytime 88%, overnight 69%). Key causes of cardiac arrest were patient factors in 92%, surgical factors in 72% and anaesthesia factors 26%, compared with 82%, 35% and 40%, respectively, in all NAP7 cases. In 24% postoperative care was a key cause. Main causes included cardiac ischaemia (21%), ventricular fibrillation (13%), massive bleeding (12%), tamponade (10%) and bradyarrhythmias (7%). 'Temporary cardiac pacing' was flagged as a contributing factor. Implementation of Cardiac Surgery Advanced Life Support (CALS) practices commonly led to prompt management of tamponade or bleeding through immediate re-sternotomy, and was highlighted positively by reporters and reviewers. While only 2% of judgements of quality of care were rated as poor, nine patients (18%) had some aspect of their care judged as poor or good and poor. Debriefs were less common in cardiac arrest reports than in other NAP7 cases, especially when patients survived.

Approximately one-third of UK hospitals offer 24-hour primary percutaneous coronary intervention services. **Interventional cardiology and electrophysiology** represent 1% of anaesthetic caseload. Cardiology was ranked fifth in the prevalence of cardiac arrests, accounting for 6.1%, with almost all occurring in the catheter laboratory during a procedure. The most common cause was cardiac ischaemia. Common themes were cardiogenic shock, transcatheter aortic valve implantation (TAVI), late involvement of anaesthesia and poor communication. A consultant or post-CCT doctor was present at the start of anaesthesia intervention in 68% of cases, fewer than for non-cardiological procedures (88%). Survival was lower than other NAP7 cases of the time of the event (61% vs 76%) and at the time of reporting (48% vs 61%). Rates of adult extracorporeal cardiopulmonary resuscitation (eCPR) were low: 1.1% of all adult cases and 17% of cardiology-associated cardiac arrests. Among 23 deaths, 10 were judged part of an inexorable process and 6

## Key findings

partially so. A quarter of patients were judged to have had poor or good and poor care, mostly before cardiac arrest, and half of these patients died.

**Obesity** created a signal in NAP7 but mostly when BMI exceeded 40 kg m<sup>-2</sup>. An increase in population BMI over the last decade means that the median BMI of surgical patients is now in the overweight category with 59% of patients overweight or obese. The degree of obesity has increased too. In the Activity Survey airway, breathing, circulatory and metabolic complications increased as patient BMI rose, especially in patients with BMI greater than 50 kg m<sup>-2</sup>. Obesity was not an obvious signal in cases of perioperative cardiac arrest reported to NAP7, but this may have been hidden by the fact that average BMI of surgical patients is not far off 30 kg m<sup>-2</sup> and patients with a BMI > 40 kg m<sup>-2</sup> account for a relatively small proportion (4.6%) of the population meaning numbers are small. Most impact appeared to be in patients with BMI >40 kg m<sup>-2</sup> and included poor preoperative risk assessment and increases in hypoxaemia, and possibly pulmonary embolus, as causes. Patients with obesity appeared less likely to receive regional anaesthesia and as BMI rose more likely to receive neuraxial anaesthesia and sedation as sole techniques. Airway and obstetrics were areas where the obesity signal was highest. In patients with a BMI >40 kg m<sup>-2</sup> survival rates were lower than in other patients (at the time of cardiac arrest 63% vs 75% and when reported to NAP7 51% vs 60%) and quality of care was judged to be good less often and poor more often.

**Obstetric anaesthetic** activity accounts for 13% of anaesthetic caseload, 70% of caseload at night and ≈360,000 obstetric anaesthetic encounters per annum, of which approximately half are caesarean sections and one-third labour analgesia. Trends in obesity seen in other patients were even more prominent in obstetric patients (median BMI 27.1 kg m<sup>-2</sup>, 62% overweight or obese). Compared with overall obstetric activity, obstetric patients were under-represented in reports to NAP7 (3.2% of reports, an incidence of 1 in 12,700). The incidence of cardiac arrest during obstetric general anaesthesia was 1 in 1,220 and during regional anaesthesia 1 in 17,000. Twenty-two cases involved women undergoing caesarean section, an incidence of 1 in 8,600, and two cases neuraxial analgesia for labour, an incidence of 1 in 56,500. Five women died: a mortality rate of 1.4 per in 100,000 (1 in 71,000) anaesthetic interventions. Compared with the Activity Survey, patients reported to NAP7 after obstetric cardiac arrests were more often overweight or obese and Black (21% vs 6%): small numbers mean these results need cautious interpretation. Haemorrhage, high neuraxial block and bradyarrhythmia were the most frequent causes of cardiac arrest, accounting for 68% of cases. Anaesthesia was judged a key cause of cardiac arrest in 68% of obstetric cardiac arrests compared with 40% in all NAP7 cases (patient 54%, surgery 29%). Care before cardiac arrest was judged good less often and poor more often in obstetric cases than in the overall dataset. In the Baseline Survey attending an obstetric cardiac arrest was associated with an increased frequency of the anaesthetist

reporting a psychological impact and an effect on their ability to deliver future care and this was reported in two cases reported to NAP7.

**Neurosurgery and neuroradiology** accounted for 1.8% of Activity Survey caseload and 3% of NAP7 cases. Main causes of cardiac arrest were haemorrhage (including airway haemorrhage) in 38% and bradycardia in 27%, with patient factors a key cause in 65% cases, anaesthesia and surgery each in 35%. Ten (38%) patients died, judged part of an inexorable process in four cases and partially so in three. Debriefs were performed in 54% cases.

The vast majority (91%) of anaesthetic departments provided **anaesthesia in remote sites**. The Baseline Survey identified these locations had lower provision of emergency equipment. Remote site anaesthesia accounted for 11% of anaesthetic caseload in the Activity Survey and 4.3% of NAP7 cases of cardiac arrest. Most specialties undertaking remote location procedures undertook relatively low risk procedures, mostly in working hours and were under-represented in NAP7 cases. Radiology and cardiology (discussed above) were marked exceptions.

**Radiology** accounted for 1.7% of anaesthesia caseload in the Activity Survey and 2.6% of NAP7 reports. Cases typically involved urgent, complex, out of hours work and often patients who were older and comorbid or unwell. Most radiology cardiac arrests occurred in interventional radiology, but with several in the CT scanner or post-procedure. Haemorrhage was the leading cause of arrest, followed by cardiac arrhythmias. Outcomes were poor with a 52% mortality rate. Patient factors and anaesthesia factors were common key causes.

**Regional anaesthesia** was used in 14% of cases in the Activity Survey and was a contributory factor in 0.4% of NAP7 cases.

**Endoscopy** accounted for 1.1% of anaesthesia workload in the Activity Survey and 0.3% of reports to NAP7. Major haemorrhage was the common cause and reviewers noted concerns about preprocedural investigations, observations, risk assessment and teamwork in the management of gastrointestinal haemorrhage.

**Ophthalmology** accounted for 4.3% of anaesthesia caseload in the Activity Survey and 0.6% of NAP7 cases. These cardiac arrests were commonly due to bradycardia, as a primary event or caused by the oculocardiac reflex. All were brief (< 10 minutes) with 100% survival.

**Dental** cases accounted for 3.1% of anaesthesia workload in the Activity Survey and 0.6% of NAP7 cases. Most were bradyarrhythmias and resuscitation generally lasted < 10 minutes with 100% survival.

**Psychiatry** accounted for 0.6% of anaesthesia workload in the Activity Survey and 0.2% of NAP7 cases. Both were postoperatively and brief (seizures relating to electroconvulsive therapy (ECT) and hyperkalaemia following suxamethonium use). Both patients survived.



The **emergency department** accounted for 2.8% of cases reported to NAP7 including 18 adults and 7 children: 15 in the emergency department and 10 in the special inclusion criteria after emergency department care. Major haemorrhage was the primary cause in 40% of cases. Of the 15 cases of cardiac arrest in the emergency department 8 died, with 6 deaths deemed at least partially part of an inexorable process. Of 10 special inclusion cases, all were high-risk cases and 9 died, with 7 of these deaths deemed at least partially inexorable.

In the Activity Survey the distribution of **ethnicities** overall and across age groups was similar to the general population. Among younger patients having anaesthesia care there was a greater proportion of non-White ethnic patients who had a perioperative cardiac arrest. Black patients account for 6.1% of the overall obstetric anaesthetic population but had 28% of cardiac arrests. Children of Asian and Asian British ethnicity accounted for 20% of perioperative cardiac arrests in children but only 6.6% of children in the Activity Survey. There was no difference in the NAP7 panel judgement about the care provided for White and non-White patients.

Overall, **monitoring during anaesthesia and transfer** falls below the Association of Anaesthetists' minimum standards. Compliance with monitoring recommendations during general anaesthesia was high but often not continuous, with gaps between anaesthetic room and theatre, or theatre and recovery in up to half of patients. In patients with an airway device in place after leaving theatre three quarters of patients had a gap in capnography monitoring during transfer. When neuromuscular blockade was used three quarters of patients did not have the recommended quantitative monitoring. Processed EEG monitoring has risen 6-fold in the last decade, while the use of total intravenous anaesthesia has risen 3-fold. Consistent with these findings, in case review there were examples of cardiac arrest where deterioration may have been detected earlier if **continuous monitoring** had been used during patient transfer.

The Baseline Survey indicated that use of **an anaesthetic room** for induction of anaesthesia was the norm before and after the pandemic (79% of hospitals), but not during it, with an overall reduction over time. In the Activity Survey, an anaesthetic room was used for 55% of all cases, 65% of non-obstetric general anaesthetics cases including 70% of elective surgery, 56% of emergency surgery, 72% of children and 64% of adults. One third of cases were not monitored during transfer to the operating room. An anaesthetic room was used in 63% of cases reported to NAP7 (of those occurring in a theatre suite). In 136 cases an anaesthetic room was used and the patient arrested before the start of surgery: 46% in the anaesthetic room, 7% during transfer and 41% after induction but before surgery started. In a small number of cases the panel commented on the inappropriate use of an anaesthetic room. In these 136 cases, anaesthesia was judged a key cause of cardiac arrest in more cases than in other cases and the panel judged care to be less good than care in all NAP7 cases.

There were 137 (16%) **postoperative cardiac arrests** reported to NAP7: 22% in recovery, 55% in critical care and 23% in wards. This will underestimate the true number of post operative cardiac arrests as reporting rates are likely to be lower than in theatre cases. In one-third of 30 recovery cases the panel judged that there were omissions in monitoring and a failure to detect or treat deterioration before the cardiac arrest occurred, including during transfers to recovery. In 52 **critical care cases**, themes included delays in interventions or providing supportive care; cardiac arrests during a medical intervention or during patient movement and deficient monitoring, including during transfer to critical care. In 26 **cardiac critical care** cases we noted widespread use of Cardiac Advanced Life Support (CALs) with generally good standards of care. Issues related to temporary cardiac pacing were noted in several cases. Of 31 **ward cases**, one-third were in patients who the panel assessed were receiving a level of care that was too low for their levels of risk and requirements for monitoring or care.

Most (84%) of anaesthetists felt **confident in leading a cardiac arrest** on the operating table, with males more confident than females, while 70% stated they would benefit from more training. Fewer than 50% believed that the current guidelines on the management of perioperative arrests are sufficient. Communication with the patient's family or next of kin following perioperative cardiac arrest involved anaesthetists in over 60% of cases but anaesthetists expressed more confidence in managing cardiac arrest than managing such communication or debriefs after cardiac arrest.

In the Baseline Survey 4.5% of responding anaesthetists reported that **experience at a recent cardiac arrest** impacted their ability to deliver future patient care, and this was reported in 3.4% of cases reported to NAP7 with a further 5.2% declining to answer this question. Despite generally good provision of informal wellbeing support to anaesthetists from colleagues, formal wellbeing support was uncommon. Anaesthetists reported generally adverse psychological impact of attending their most recent cardiac arrest. Over their entire career such attendance was viewed positively more often than negatively professionally but the impact on individuals' private lives was more often negative.

NAP7 was planned just before the **COVID-19 pandemic**. Data collection for the main project was delayed for 13-months as a result of the first two major surges. During this time the project was redesigned and as part of that the Anaesthesia and Critical Care Covid Tracking survey was undertaken to assess the extent to which services and care were disrupted. During January 2021, critical care in the UK was largely overwhelmed. Almost one third of anaesthesia staff were unavailable (mostly redeployed to ICU which increased critical care workforce by 125%). Three-quarters of critical care units were so expanded that planned surgery could not be safely resumed. At all times, the greatest resource limitation was staff. A significant proportion (42%) of theatres were closed, and those that were open operated at



## Key findings

significantly reduced activity levels. National surgical activity reduced dramatically including reduced elective surgery, and in some regions paediatric surgery reduced to 12% of normal activity. Overall surgical activity reduced to less than 50% of normal activity, losing some 10,000 operations each day. Owing to lower response rates from the most pressed regions and hospitals, these results may underestimate the true impact.