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Original Article

Peri-operative cardiac arrest: epidemiology and clinical features of patients analysed in the 7th National Audit Project of the Royal College of Anaesthetists

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Summary

The 7th National Audit Project of the Royal College of Anaesthetists studied peri-operative cardiac arrest in the UK, a topic of importance to patients, anaesthetists and surgeons. Here we report the results of the 12-month registry, from 16 June 2021 to 15 June 2022, focusing on epidemiology and clinical features. We reviewed 881 cases of peri-operative cardiac arrest, giving an incidence of 3 in 10,000 anaesthetics (95%CI 3.0–3.5 per 10,000). Incidence varied with patient and surgical factors. Compared with denominator survey activity, patients with cardiac arrest: included more males (56% vs. 42%); were older (median (IQR) age 60.5 (40.5–80.5) vs. 50.5 (30.5–70.5) y), although the age distribution was bimodal, with infants and patients aged > 66 y overrepresented; and were notably more comorbid (73% ASA physical status 3–5 vs. 27% ASA physical status 1–2). The surgical case-mix included more weekend (14% vs. 11%), out-of-hours (19% vs. 10%), non-elective (65% vs. 30%) and major/complex cases (60% vs. 28%). Cardiac arrest was most prevalent in orthopaedic trauma (12%), lower gastrointestinal surgery (10%), cardiac surgery (9%), vascular surgery (8%) and interventional cardiology (6%). Specialities with the highest proportion of cases relative to denominator activity were: cardiac surgery (9% vs. 1%); cardiology (8% vs. 1%); and vascular surgery (8% vs. 2%). The most common causes of cardiac arrest were: major haemorrhage (17%); bradyarrhythmia (9%); and cardiac ischaemia (7%). Patient factors were judged a key cause of cardiac arrest in 82% of cases, anaesthesia in 40% and surgery in 35%.

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Introduction

Peri-operative cardiac arrest is a complication feared by patients, anaesthetists and surgeons [1]. Recent estimates put the incidence of cardiac arrest in the peri-operative period at 2–13 per 10,000 anaesthetics, with 32–75% of patients dying before discharge from hospital [2–7]. Variability may be due to case-mix and complexity, reporting methods and healthcare setting. For example,

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cardiac, transplant and vascular surgery have high relative risks, as do patients who are older, have significant cardiorespiratory comorbidities or are undergoing emergency surgery [6].

The absence of systematic reporting of peri-operative cardiac arrest in the UK means that the incidence, management and outcomes of these events are unknown. Existing UK national audits report on out-of-hospital cardiac arrest treated by ambulance services [8], and in-hospital arrests attended by the hospital resuscitation team following an emergency (2222) call [9]. However, most peri-operative events are missed as no such call is made.

The importance and incomplete understanding of the topic contributed to peri-operative cardiac arrest being chosen as the subject of the 7th National Audit Project (NAP7) of the Royal College of Anaesthetists (RCoA) [1]. As with previous projects, there are three core components: a baseline survey of UK anaesthetists and Anaesthesia Associates [10, 11]; an activity survey to gather denominator data on UK anaesthetic practice [12]; and a case registry and expert review of events occurring over a 12-month period.

This paper relates to the case registry phase and describes the epidemiology and clinical features of peri-operative cardiac arrest cases reported to NAP7. The management and outcome of these events are reported separately [13].

Methods

Detailed methods of NAP7 have been described previously [14]. Peri-operative cardiac arrest was defined as ≥ 5 compressions and/or defibrillation in a patient having a procedure under the care of an anaesthetist. The peri-operative period was defined as from the WHO sign-in or first hands-on contact with a patient to 24 h after the handover of the patient to PACU or another clinician (e.g. ICU or ward care) or hospital discharge (if this occurred before 24 h). In addition to these core definitions, there were several special inclusion criteria [14].

We did not study the following: cardiac arrest before an anaesthetist attended; defibrillation during electrophysiological procedures when this is an expected part of the procedure; and patients who were ASA physical status 6.

Case reporting was through a secure encrypted case submission website (online Supporting Information Appendix S2) and included: anonymised details of patient; procedure characteristics; anaesthesia care; the cardiac arrest and its management; and patient outcomes. Case reporters were also able to include details of unanticipated events which were considered to have contributed to or caused cardiac arrest. Eligible cases were reviewed by a multidisciplinary panel using a structured `full´ or `rapid´ review form [14, 15].

For each case, the review panel assigned one or more key causes of cardiac arrest (i.e. patient, surgery, anaesthesia, organisational, postoperative care) and also

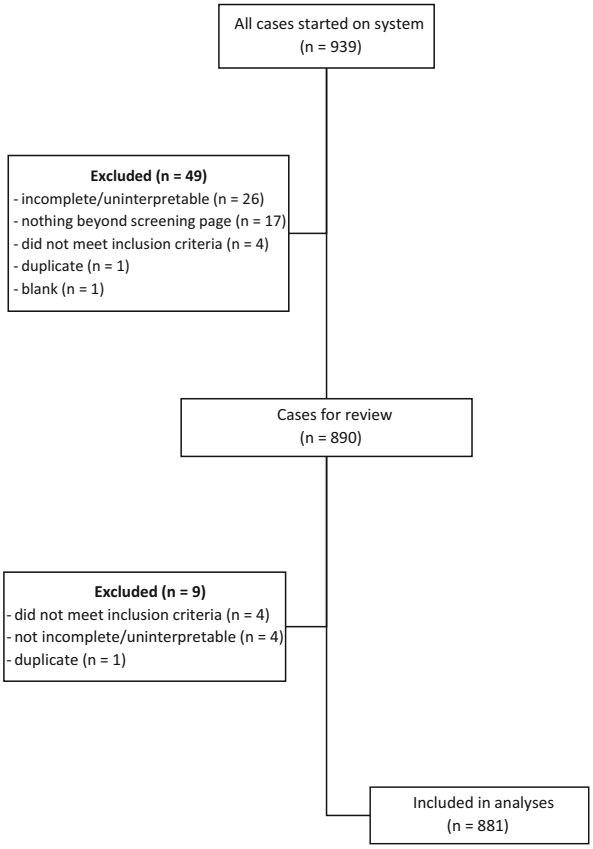


Figure 1 Flow chart of NAP7 case reports.

Table 1 Breakdown of case types reported to NAP7.

	n = 881
Adult (aged > 18 y) and non-obstetric	718 (81%)
• Non-cardiac	614 (70%)
• Cardiac	50 (6%)
• Cardiology	54 (6%)
Obstetrics (excluding labour analgesia)	22 (2%)
Paediatrics	102 (12%)
Special inclusion criteria	39 (4%)
• Critically ill child before transfer	13 (1%)
• Emergency department	19* (2%)
• Obstetric analgesia	6 (< 1%)
• Regional block outside theatre	1 (< 1%)

*Two aged ≤ 18 y.

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the specific cause(s) (up to three per case, e.g. haemorrhage, hyperkalaemia). Assignment of anaesthesia or surgery as a cause does not indicate blame or error.

Estimates for median age were based on where the median value was expected to be within a group, assuming that the population was distributed evenly within it. These values were collected as categorical

Table 2 Estimated incidence of cardiac arrest and death due to no sustained return of spontaneous circulation (ROSC) for different subgroups of cases.

Group	Estimated denominator from activity survey data	Cases reported	Incidence of cardiac arrest	Number of deaths (no ROSC)	Incidence of death
ASA physical status 1	660,000	62	0.01%, 1 in 10,645 (95%CI 1 in 8244–13,774)	5	0.001%, 1 in 132,000 (95%CI 1 in 53,220–358,423)
ASA physical status 1–2	1,990,000	235	0.01%, 1 in 8468 (95%CI 1 in 7463–9615)	21	0.001%, 1 in 94,762 (95%CI 1 in 60,976–149,254)
All elective cases	1,590,000	242	0.02%, 1 in 6570 (95%CI 1 in 5780–7463)	17	0.001%, 1 in 93,529 (95%CI 1 in 57,110–155,521)

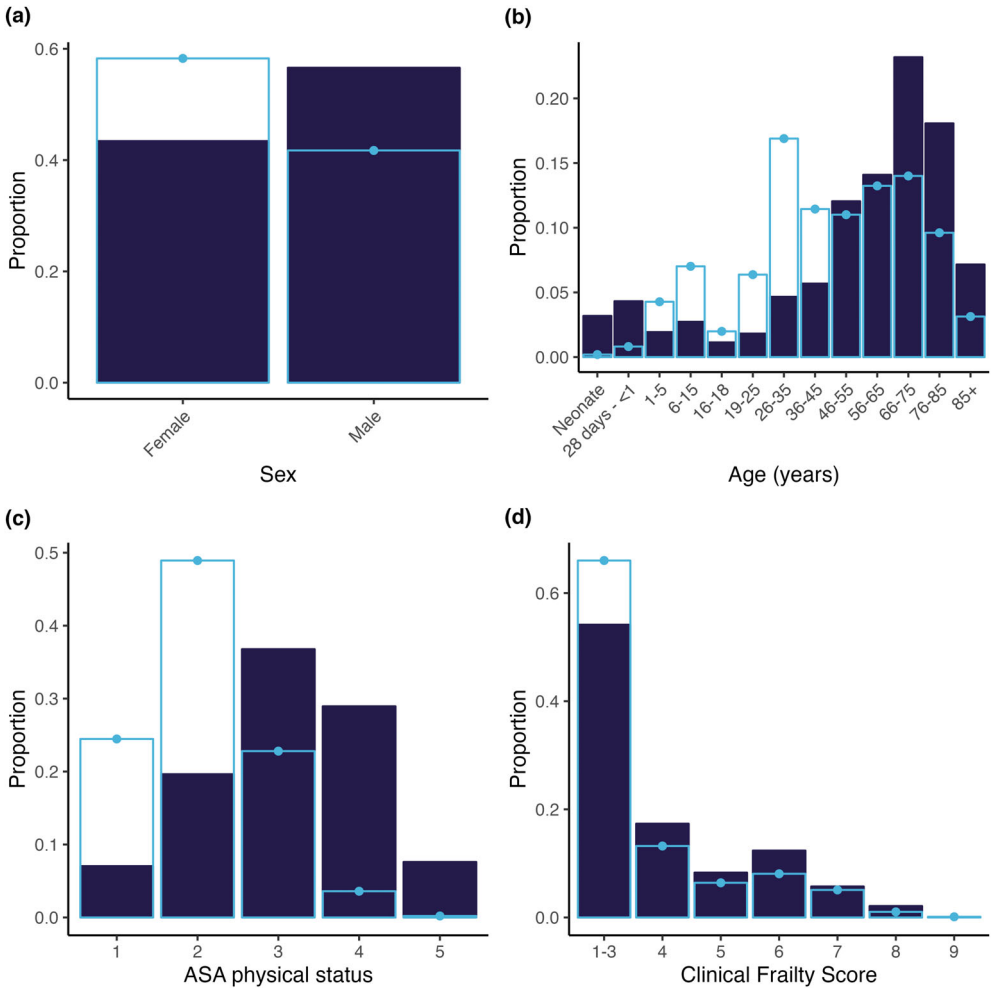


Figure 2 Patient characteristics of NAP7 cases (purple filled bars) and activity survey data (blue lines) showing: (a) sex; (b) age; (c) ASA physical status; and (d) clinical frailty score. Where a purple bar is notably above or below the blue line, the characteristic is over or underrepresented, respectively, among patients who had a cardiac arrest.

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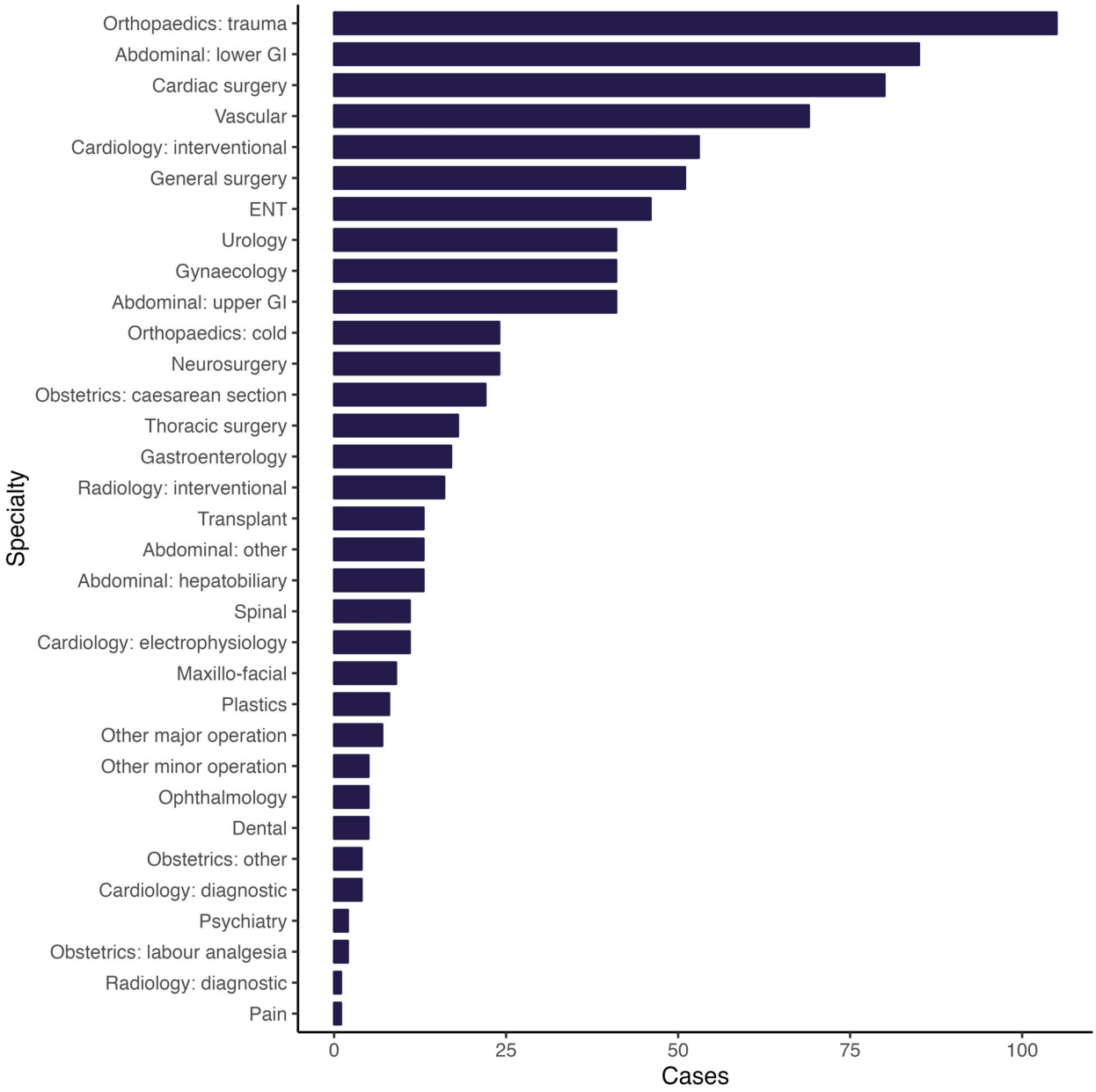


Figure 3 Prevalence of peri-operative cardiac arrests reported to NAP7 by surgical speciality. Cases where surgical speciality not applicable are not shown. Numerical data are provided in online Supporting Information Appendix S8 (Appendix S5).

variables in ranges to reduce the risk of reverse identification. Incidence rates of events (e.g. cardiac arrest) were calculated using denominator data from the NAP7 activity survey [12]. In addition to analysing the whole data set, we also considered the subgroup of patients who met the core inclusion criteria (i.e. were not reported under one of the special inclusion criteria) but were not having cardiac surgery or obstetric procedures. Data analysis was performed using R (R Core Team, Vienna, Austria).

Results

We report the results from the 12-month registry period from 16 June 2021 to 15 June 2022, during which reports of peri-operative cardiac arrest were collected. In total, 939 cases were entered into the online case reporting database, 881 of which were eligible for inclusion in the final analyses (Fig. 1). In total, 198 (22%) cases underwent full panel review only; 104 (12%) rapid review followed by full panel review; and 579 (66%) rapid review only. Of 842 cases included under the core

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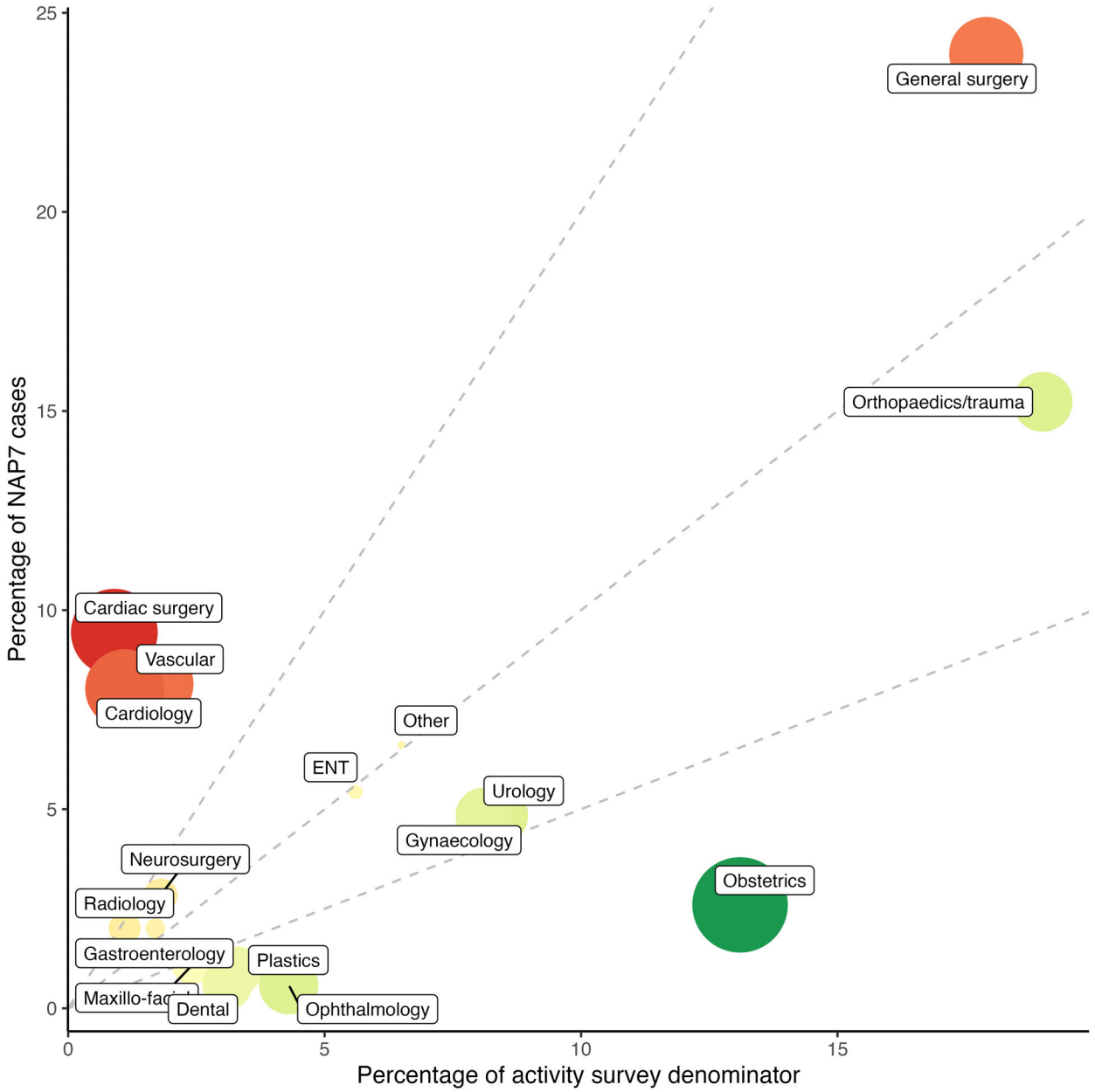


Figure 4 Relative risk of cardiac arrest by speciality. Size of coloured circle indicates magnitude of difference between proportion of cases in activity survey and case registry. Colour of circle is scale on which green circles are relatively underrepresented in the case registry and red circles relatively overrepresented. Dashed lines represent 2:1, 1:1 and 1:2 ratios.

inclusion criteria, 740 (88%) reports were of adults (age > 18 y), 22 (3%) of whom were obstetric patients. There were 39 reports included under one of the special inclusion criteria (Table 1).

Using the activity survey estimated denominator of 2.71 million cases per year [12] gives an incidence of peri-operative cardiac arrest of 1 in 3076 or approximately 3 in 10,000 anaesthetics. Some 209 (24%) patients did not survive the initial event, with no sustained return of spontaneous circulation (ROSC), giving an approximate incidence of early death of 1 in 12,967. These incidences were lower in patients who were ASA physical status 1–2 and had elective surgery (Table 2). Excluding 56 cases from areas not covered by the activity survey (i.e. the independent sector and those reported under the special inclusion criteria) gives similar estimates of 3 in 10,000 and 1 in 14,188 for peri-operative cardiac arrest and early death, respectively.

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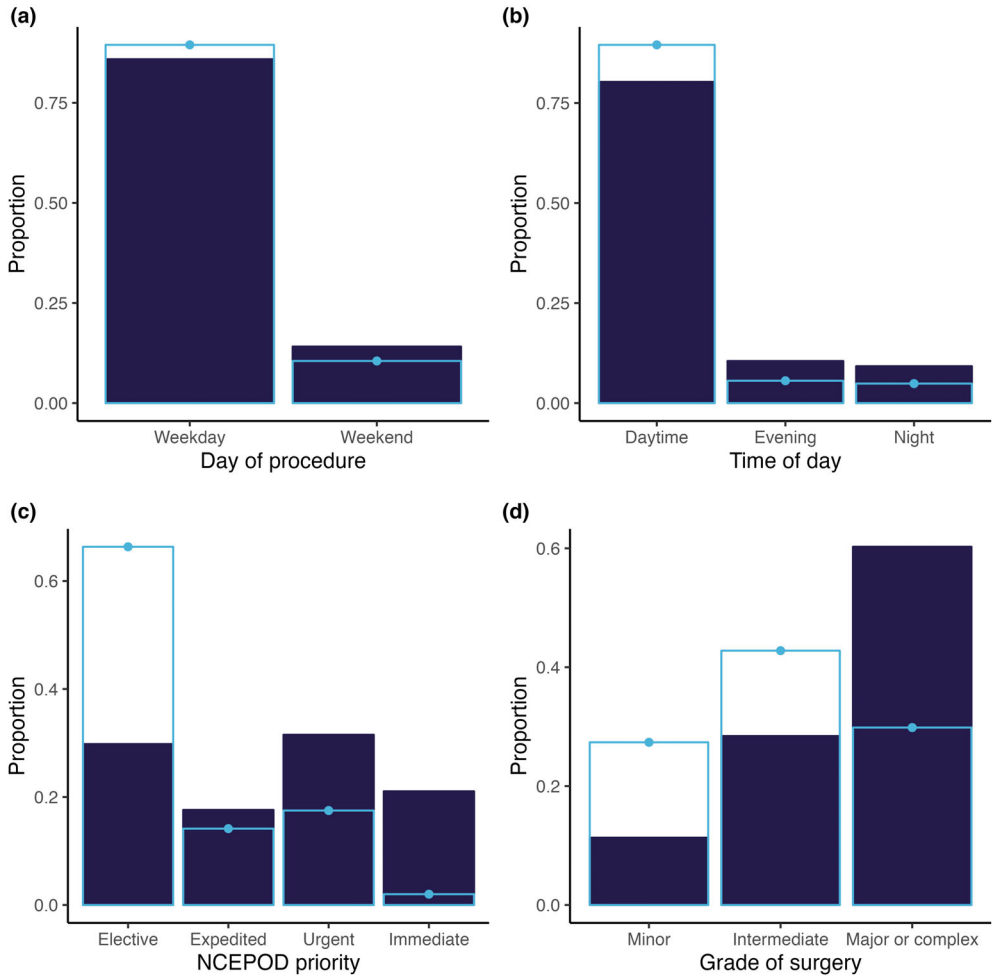


Figure 5 Case characteristics of NAP7 cases (filled purple bars) and activity survey data (blue lines) showing: (a) day of the week; (b) time of day (daytime 08.00–17.59, evening 18.00–23.59, night 00.00–07.59); (c) National Confidential Enquiry into Patient Outcome and Death (NCEPOD) priority; and (d) grade of surgery. Where a purple bar is notably above or below the blue line, the characteristic is over or underrepresented, respectively, among patients who had a cardiac arrest.

Compared with the denominator data, the patients who had a cardiac arrest included more males and were older, although the age distribution was bimodal, with infants and patients aged > 66 y being overrepresented (Fig. 2 and online Supporting Information Appendix S3). Patients who had a cardiac arrest were also more comorbid and modestly frailer. These differences persisted in the subset of cases that were adult, non-cardiac, non-obstetric, and non-special inclusion criteria, becoming more pronounced for non-elective cases (online Supporting Information Appendix S4). The proportion of patients who were obese was similar in the overall cohort compared with the activity survey. However, the proportion was notably higher in the adult, non-cardiac, non-obstetric, non-special inclusion criteria, and non-elective cohort compared with the equivalent denominator data (34% vs. 27%) (online Supporting Information Appendix S4).

The specialties in which cardiac arrest was most prevalent were orthopaedic trauma (105, 12%); lower gastrointestinal surgery (85, 10%); cardiac surgery (80, 9%); vascular surgery (69, 8%); and interventional cardiology (41, 6%) (Fig. 3 and online Supporting Information Appendix S5). The specialities with the highest incidence of cardiac arrest (compared with the activity survey denominator) were cardiac surgery (9% vs. 1%), cardiology (8% vs. 1%) and vascular surgery (8% vs. 2%). Conversely, obstetric cardiac arrests were underrepresented (3% vs. 13%) relative to the activity survey denominator (Fig. 4 and online Supporting Information Appendix S5). In the subset of cases that were adult, non-cardiac, non-obstetric and

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Table 3 Characteristics of NAP7 cases and activity survey denominator data. Values are number (proportion).

	All cases n = 881	Activity survey n = 24,172	Relative proportion (95%CI)
Day of the week			
Weekday	718 (85%)	21,629 (89%)	0.95 (0.91–0.98)
Weekend	118 (14%)	2543 (11%)	1.32 (1.07–1.62)
Public holiday	12 (1%)	0	
Unknown	33 (4%)	0	
Time of case start			
Daytime (08.00–17.59)	680 (80%)	21,644 (90%)	0.9 (0.86–0.93)
Evening (18.00–23.59)	89 (11%)	1350 (6%)	1.88 (1.46–2.42)
Night (00.00–07.59)	78 (9%)	1178 (5%)	1.89 (1.43–2.48)
Unknown	34 (4%)	0	-
Priority			
Immediate	171 (21%)	429 (2%)	10.69 (8.47–13.43)
Urgent	256 (31%)	3746 (17%)	1.83 (1.60–2.09)
Expedited	143 (17%)	3028 (14%)	1.27 (1.05–1.52)
Elective	242 (29%)	14,201 (64%)	0.46 (0.41–0.51)
Not applicable	11 (1%)	669 (3%)	0.44 (0.22–0.87)
Unknown	58 (7%)	2099 (9%)	
Grade of surgery			
Minor	96 (11%)	6113 (26%)	0.44 (0.35–0.54)
Intermediate	241 (28%)	9556 (40%)	0.71 (0.62–0.80)
Major or complex	511 (60%)	6667 (28%)	2.15 (1.98–2.31)
Not applicable	0	1397 (6%)	-
Unknown	33 (4%)	439 (2%)	-
Mode of anaesthesia			
General	617 (73%)	14,491 (63%)	1.16 (1.10–1.22)
General and neuraxial	53 (6%)	750 (3%)	1.93 (1.37–2.70)
General and regional	64 (8%)	1665 (7%)	1.05 (0.78–1.40)
Intravenous analgesia only	2 (< 1%)	0	-
Local infiltration	2 (< 1%)	0	-
Monitoring only	9 (1%)	168 (1%)	1.46 (0.61–3.35)
Neuraxial	46 (5%)	3542 (15%)	0.35 (0.26–0.49)
Neuraxial and sedation	26 (3%)	792 (3%)	0.9 (0.56–1.42)
Regional anaesthesia	3 (< 1%)	736 (3%)	0.11 (0.03–0.38)
Regional and sedation	2 (< 1%)	179 (1%)	0.31 (0.05–1.42)
Sedation	23 (3%)	826 (4%)	0.76 (0.46–1.23)
Unknown	34 (4%)	1023 (4%)	-

Relative proportion (95%CI) is calculated as proportion of cardiac arrest cases divided by proportion of activity survey cases. Values < 1 indicate underrepresentation in cardiac arrest cases and values > 1 represent overrepresentation.

non-special inclusion criteria, the specialities in which cardiac arrest during elective surgery was most prevalent were gynaecology, urology and orthopaedic surgery. For non-elective cases, cardiac arrest was most prevalent for orthopaedic trauma surgery, lower gastrointestinal surgery and vascular surgery (online Supporting Information Appendix S6).

Although most cardiac arrests occurred during weekdays and in cases that started during daytime hours, the proportions were lower than in the denominator data, with weekend days and out-of-hours being overrepresented. This is consistent with the fact that cardiac arrest occurred more often in patients whose surgery was urgent or immediate surgical priority. Cardiac arrest

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Table 4 Clinical details of cardiac arrest cases reported to NAP7. Values are number (proportion).

	n = 881
Phase	
Pre-induction	15 (2%)
Induction	118 (13%)
Transfer to theatre	15 (2%)
After induction, before surgery	117 (13%)
During surgery – GA	297 (34%)
During surgery – LA/RA	57 (7%)
Conversion to GA	5 (1%)
Emergence/extubation	42 (5%)
Transfer to PACU	15 (2%)
Postoperative – in PACU	38 (4%)
Postoperative – after PACU discharge	148 (17%)
N/A: special inclusion criteria	14 (2%)
Cardiac arrest location	
Anaesthetic room	95 (11%)
Cardiac catheter laboratory	54 (6%)
Critical care area	110 (12%)
CT	3 (<1%)
Emergency department	17 (2%)
Endoscopy	3 (<1%)
Interventional radiology	10 (1%)
Labour ward	4 (1%)
Neuroradiology	4 (1%)
Other	9 (1%)
Pacing room	2 (<1%)
Recovery	32 (4%)
Theatre: day surgery unit	19 (2%)
Theatre: main theatre suite	450 (51%)
Theatre: obstetrics	19 (2%)
Theatre: other	12 (1%)
Ward	38 (4%)

GA, general anaesthesia; LA, local anaesthesia; CT, computed tomography; PACU, post-anaesthesia care unit.

was also more prevalent in patients undergoing major or complex grades of surgery (Fig. 5 and Table 3). The senior anaesthetist at induction for 842 non-special inclusion cases was a consultant in 726 (86%) cases. The remaining cases were managed by a specialist, associate specialist or speciality (SAS) doctor (45, 5%); doctor with a certificate of completion of training/certificate of eligibility for specialist registration (CCT/CESR) (8, 1%); speciality trainee (ST) ≥ year 5 (43, 5%); ST year 3–4 (15, 2%); or a core trainee (5, 1%). While the proportion of cases with a consultant present for induction varied between in and out of hours, a consultant was present for 59 (75%) cases occurring at night (00.00–07.59).

There were 734 (87%) cardiac arrests in patients who received general anaesthesia. Type of anaesthesia did not show clear associations but among reports of cardiac arrest to NAP7, general anaesthesia was modestly overrepresented (87% vs. 73%), and neuraxial anaesthesia (alone or with sedation) was underrepresented (9% vs. 18%). This is likely to reflect surgical case-mix and urgency (Fig. 5 and Table 3). Just over half of cardiac arrests occurred in theatres within the main operating theatre suite but with substantial proportions in critical care and anaesthetic rooms (Table 4). In-theatre reports accounted for 500 (57%) cases and isolated locations for 81 (9%) of cases. The cardiac catheter laboratory was the location of 54 (6%) of cardiac arrests despite representing < 1% of all anaesthetic activity. Cardiac arrests were relatively infrequent during transfer and in the post-anaesthesia care unit (PACU). The most common peri-operative phase of cardiac arrest was during surgery with general anaesthesia, followed by induction of general anaesthesia or after induction before surgery started (Fig. 6).

The most reported unanticipated events (both causal and contributory) were: major haemorrhage with 90 (10%) causal and 37 (4%) contributory; bradyarrhythmia with 66 (8%) causal and 42 (5%) contributory; and isolated severe hypotension with 44 (5%) causal and 30 (3%) contributory. Unexpected airway events contributed to 59 (7%) cardiac arrests.

For the whole cohort, the most frequently reported key cause was patient factors (719, 82%) and for 219 (25%) reports, patient factors were judged the sole cause (Fig. 7). Anaesthesia was assigned as a cause more often than surgery (Fig. 7). In the subset of adult, non-cardiac, non-obstetric, non-special inclusion criteria cases, patient factors remained most common (485, 79%) but most often with anaesthesia (144, 24%). When this subset is split into elective and non-elective, patient factors were reported in 136 (56%) elective and 575 (90%) non-elective reports. The subset in which anaesthesia and surgery were each most implicated was the elective group: 101 (52%) and 75 (39%), respectively.

Across all cases, the most common primary specific cause assigned by the NAP7 review panel was major haemorrhage accounting for 149 (17%) cases (Table 5). For causes described as `other´, the most common were anaesthesia/drug-induced and cardiac failure/cardiogenic shock, accounting for 11 (1%) each (online Supporting Information Appendix S7). The most common cause of cardiac arrest varied by speciality (Table 6). In keeping with

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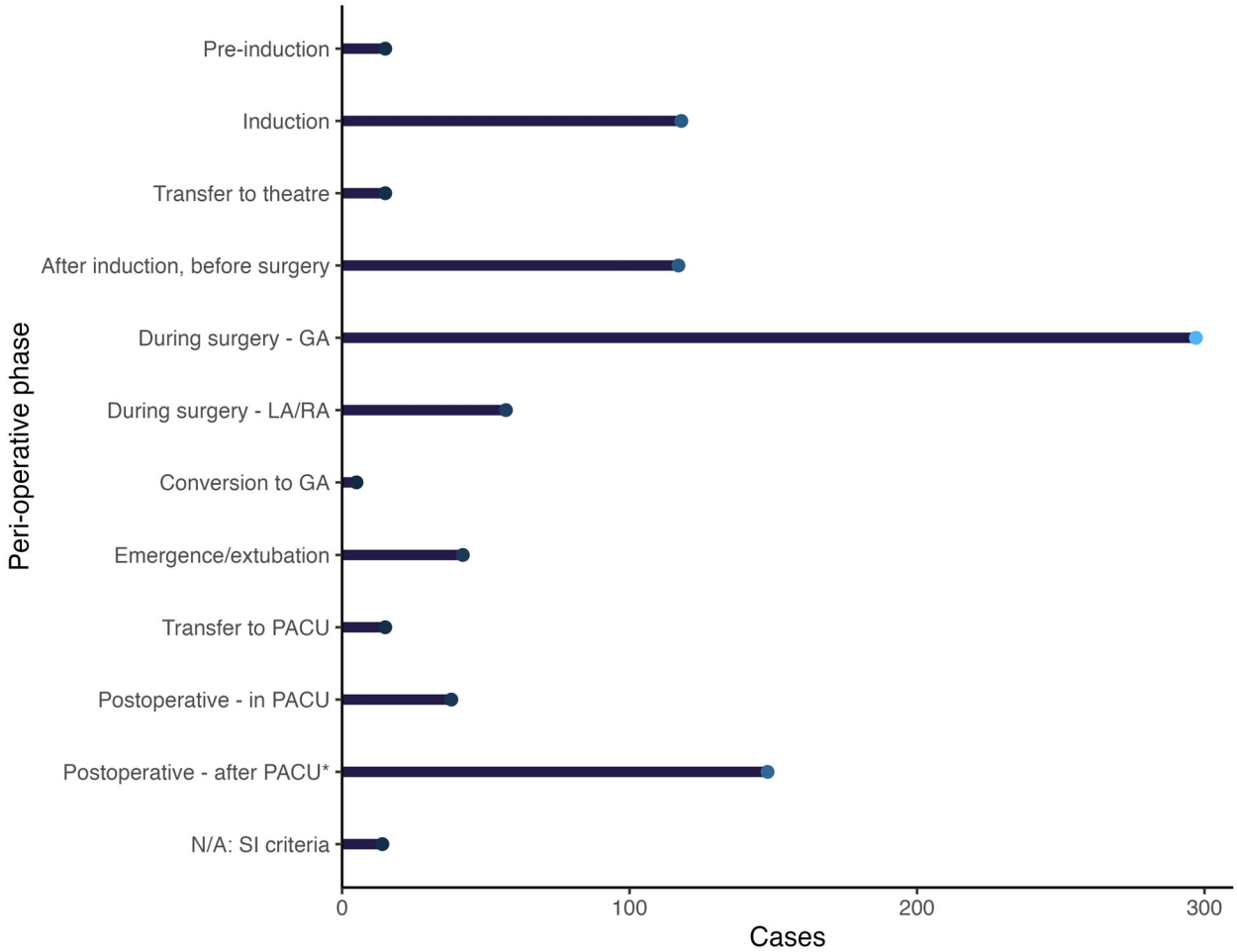


Figure 6 Peri-operative phase of cardiac arrest. GA, general anaesthetic; LA, local anaesthetic; RA, regional anaesthetic; PACU, post-anaesthesia care unit; N/A. not applicable; SI (special inclusion) criteria relates to cases for which peri-operative phase was not applicable as it was reported under one of the SI criteria; *or in critical care area if PACU not used.

the whole cohort, major haemorrhage was the leading specific cause for the adult non-cardiac, non-obstetric, non-special inclusion criteria group (114, 20%) and the non-elective subset of those (91, 23%). Within the elective subset, the most common cause was bradyarrhythmia (36, 19%) (online Supporting Information Appendix S8).

Additional case report data collected on issues including pre-operative risk scoring, use of anaesthetic rooms, monitoring during anaesthesia and drug choice and dosing will be reported elsewhere. Details of the management and outcomes of cases reported to NAP7 are presented separately [13].

Discussion

In the first UK-wide prospective audit of peri-operative cardiac arrest, we found an incidence of peri-operative cardiac arrest of approximately 3 in 10,000. The 881 reports detailed in NAP7 are the largest prospective case series to date and confirm that the population of patients experiencing peri-operative cardiac arrest was at higher risk (by type and urgency of surgery, age and comorbidity) on average than the activity survey denominator population [12]. Peri-operative cardiac arrest or death in low-risk patients was very rare. Among patients who were ASA physical status 1–2, peri-operative cardiac arrest occurred in around 1 in 8000 cases and < 1 in 100,000 died.

The incidence we report is in keeping with existing estimates from other settings [5, 7], and lower than the 5.7 per 10,000 reported in one series from the USA [6] and 13 per 10,000 in a report from Brazil [3]. Some of the observed differences may be related to differences in case-mix, for

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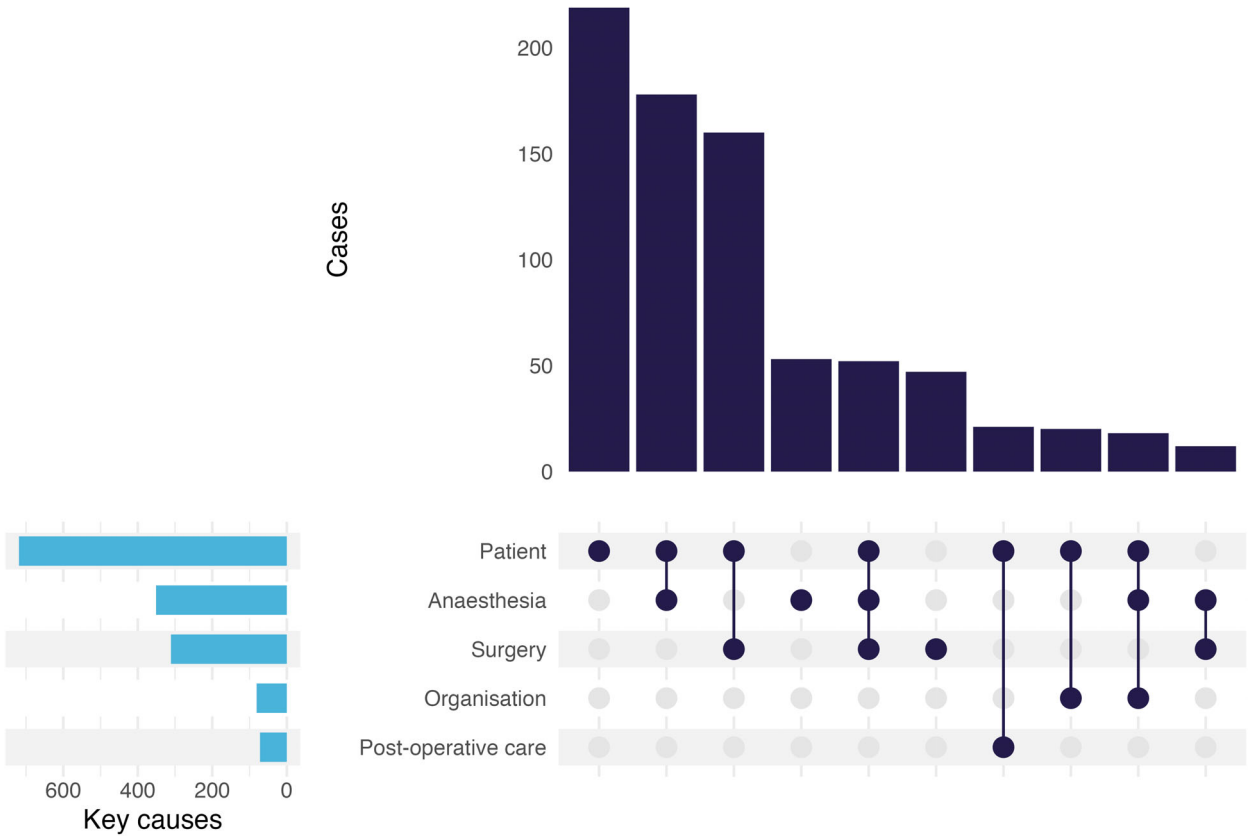


Figure 7 Panel agreed key cause(s) of cardiac arrest (top 10 combinations of 1534 key causes assigned to 854 reports).

example exclusion in other series of children [6] or cardiac surgery [7], but the similarity suggests our results have face validity.

Extremes of age were overrepresented in patients experiencing peri-operative cardiac arrest compared with activity survey denominator data, as were higher ASA physical status classes. The higher-risk nature of this population aligns with the panel review process identifying patient factors as a key cause in 82% of cases. The surgical case-mix also differed, with most cardiac arrests occurring during non-elective, major or complex surgery, with weekend and out-of-hours cases more prevalent. The finding that > 80% of all cases and three-quarters of those occurring at night had a consultant present during induction of anaesthesia suggests efforts to match clinical staffing to patient/case complexity and risk. When a consultant was not present, a senior anaesthetist able to work autonomously was commonly involved. Surgical specialities also differed, with several specialities accounting for a higher proportion of cardiac arrest cases than activity survey data, notably cardiac surgery, interventional cardiology and vascular surgery.

The most common cause of peri-operative cardiac arrest in NAP7 was haemorrhage (17%). A recent systematic review of studies reporting the causes of in-hospital cardiac arrest [16] documented that the most common cause was hypoxaemia (27%); this contrasts with our results which found that hypoxaemia was the cause in 6% of cardiac arrests. The systematic review did not report haemorrhage specifically as a cause of cardiac arrest but documented hypovolaemia as a cause in 15% of cases. These differences in aetiology highlight the fact that peri-operative cardiac arrest represents a distinct clinical context compared more broadly with in-hospital arrests. Cause of cardiac arrest varied with surgical speciality. For cardiac-related specialties, the most common cause was cardiac ischaemia; for upper and lower gastrointestinal surgery it was septic shock; for ENT it was hypoxaemia; and for pelvic specialities it was bradyarrhythmia. These data highlight the speciality-specific nature of major complications that lead to cardiac arrest and are likely a complex interaction of patient, surgical and anaesthetic factors. Haemorrhage, despite only being the most common cause in vascular surgery,

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Table 5 Primary specific cause of cardiac arrest on panel review (numbers < 5 suppressed and included in `other´). Values are number (proportion).

Cause	
Major haemorrhage	149 (17%)
Bradyarrhythmia	83 (9%)
Unknown	68 (8%)
Cardiac ischaemia	65 (7%)
Septic shock	60 (7%)
Isolated severe hypotension (central vasopressors considered/started)	54 (6%)
Severe hypoxaemia	54 (6%)
Anaphylaxis	35 (4%)
Vagal outflow (e.g. pneumoperitoneum, oculocardiac reflex)	33 (4%)
Ventricular fibrillation	26 (3%)
Bone cement implantation syndrome	20 (2%)
Drug error	16 (2%)
Pulmonary embolism	16 (2%)
Tachyarrhythmia	16 (2%)
Cardiac tamponade	15 (2%)
Complete heart block	13 (1%)
Ventricular tachycardia	13 (1%)
Significant hyperkalaemia	9 (1%)
Tension pneumothorax	8 (1%)
High neuraxial block	6 (1%)
Laryngospasm	5 (1%)
Other*	117 (13%)

*Details of causes classified under `other´ are given in online Supporting Information Appendix S7.

Table 6 Most common primary cause of cardiac arrest on panel review in specialities with at least 40 case reports. Values are number (proportion).

Speciality	Cause	
Abdominal: lower gastrointestinal	Septic shock	23/85 (27%)
Abdominal: upper gastrointestinal	Septic shock	10/41 (24%)
Cardiac surgery	Cardiac ischaemia	13/80 (16%)
Cardiology: interventional	Cardiac ischaemia	22/53 (42%)
Ear, nose and throat	Severe hypoxaemia	17/46 (37%)
General surgery	Septic shock	6/51 (12%)
Gynaecology	Bradyarrhythmia	13/41 (32%)
Orthopaedics: trauma	Other*	22/105 (21%)
Urology	Bradyarrhythmia	9/41 (22%)
Vascular	Major haemorrhage	39/69 (57%)

*Other: uncertain/unknown (10); patient factors including frailty/age/comorbid state (4); anaesthetic drugs (3); hypovolaemia (3); and cardiac failure (1).

was the general cause across all specialities, most likely as it ranked highly as a cause in most specialities.

Comparing these data with previous national audit projects (specifically NAP4 [17] which reported on airway complications and NAP6 [18] 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.

There are some limitations. While this case series represents a valuable resource from which to learn about peri-operative cardiac arrest, it is likely that we did not achieve 100% case capture over the 12-month registry period. This particularly applies to postoperative cases when anaesthetic attendance and awareness of the study may have been absent. There may also be substantial underreporting from the independent sector: < 35% of providers participated in NAP7 and only 17 (2%) cases were reported from independent sites. The nature of the data collected, and our efforts to prevent any case from becoming identifiable, necessarily limited the detail available to the review panel and may have contributed to the fact that the underlying cause of cardiac arrest could not be determined in 12% of cases. Similarly, it is likely our methodology is limited in the extent to which it can extract a broad overview of human factors involved in cases. We also sought to identify mitigating factors which may prevented cardiac arrest from occurring; however, our ability to detect these factors is limited by the fact that we only reviewed cardiac arrest cases.

The results of NAP7 represent the largest prospective study of peri-operative cardiac arrest and define this patient population in UK anaesthetic practice for the first time. We have also been able to describe how the relative risk varies in different clinical settings and identify several themes from which valuable learning can be drawn.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. List of NAP7 collaborators.

Appendix S2. Structured NAP7 case report form.

Appendix S3. Patient characteristics of NAP7 cases and activity survey denominator data.

Appendix S4. Patient demographics in subsets of cases reported to NAP7.

Appendix S5. Surgical speciality of cases reported to NAP7.

Appendix S6. Specialties with highest prevalence of cardiac arrest reported to NAP7 in patient subgroups.

Appendix S7. Specific causes of cardiac arrest classified as `other´.

Appendix S8. Panel agreed specific cause of cardiac arrest in patient subgroups.

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