39 Postoperative cardiac arrests in recovery, critical care and ward areas


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Key findings

- There were 137 (15.6%) postoperative cardiac arrests reported from 881 cardiac arrest reports to the Seventh National Audit Project (NAP7).
- A total of 30 (22%) of the reported postoperative cardiac arrests occurred in recovery, 76 (55%) in critical care units and 31 (23%) in wards.
- Cardiac arrests occurring after discharge from recovery were less likely to be reported to NAP7 than those in the presence of an anaesthetist and it is therefore inevitable that the cases reported here are only a proportion of those cardiac arrests occurring within 24 hours of surgery. This chapter focuses intentionally on the cases rather than estimating incidences of events.

Recovery (30 cardiac arrests)

- In 10 (one-third) cardiac arrests, the assessment panel judged that there should have been better patient monitoring to detect and treat deterioration before the cardiac arrest occurred, including in theatre and during transfer from theatre to the recovery area.
- Medication issues (eg drug errors) were the second most common association with cardiac arrest in recovery.

Critical care (51 cardiac arrests)

- Delays in care, either in making an intervention or providing supportive care, were associated with five cardiac arrests.
- Five cardiac arrests occurred immediately during a medical intervention.
- Five cardiac arrests in critical care were associated with physical patient movement.
- In four cardiac arrest reports, the assessment panel judged that there should have been improved patient monitoring, including in theatre and during transfer to critical care.
- Three patients had a hypoxaemic cardiac arrest with a poor outcome after loss of the airway, including two tracheostomy displacements.

Cardiac critical care (26 cardiac arrests)

- One-third of postoperative cardiac arrests in critical care included in NAP7 occurred after cardiac surgery.
- There was widespread use of Cardiac Advanced Life Support (CALS), with generally good standards of care.
- In four reports, issues related to temporary cardiac pacing were a factor in the cardiac arrest.

Ward (31 cardiac arrests)

- Ten (one-third) ward cardiac arrests were in patients assessed by the panel as being transferred to a level of care that was too low for their levels of risk and requirements for monitoring or care.

What we already know

Postoperative care

There is little specific knowledge of the incidence of cardiac arrest relating to the specific inclusion criteria used for reporting to NAP7. This period was defined as 24 hours after the handover of the patient to recovery or another clinician (eg intensive care, ward care) or when the patient left the hospital if this was within 24 hours (Chapter 6 Methods).

An analysis of perioperative cardiac arrests in the American Heart Association Get With The Guidelines®-Resuscitation registry included patients having a cardiac arrest up to 24 hours postoperatively (Ramachandran 2013). In this analysis, 42% of the 2,524 perioperative cardiac arrests occurred postoperatively and the locations of these were post-anaesthetic care unit (50%), critical care unit (37%) and ward (13%).

There is already clear understanding that postoperative outcomes can be predicted using patient-level risk scoring and that patients' outcomes are better if their postoperative care is aligned with the level of perioperative risk (Chapter 19 Risk assessment). This approach has been recommended by multiple

national reports, most recently in the guidelines *Preoperative Assessment and Optimisation for Adult Surgery* (CPOC 2021), which include the recommendations:

- All patients who are being considered for a surgical intervention should have their individual risk assessed using objective measures, combined with senior, experienced clinical judgement.
- Patients with greater than 1% predicted risk of 30-day mortality should be considered for postoperative enhanced care, and those with greater than 5% risk should be considered for postoperative critical care admission. If no enhanced care facility is available on site, a surgical level 2 or 3 admission should be considered.

All patients in an acute hospital setting should have a clear physiological monitoring plan including a track and trigger system for action on physiological derangements, as outlined in the National Institute for Health and Care Excellence guideline *Acutely Ill Adults in Hospital: Recognising and Responding to Deterioration* (NICE 2007).

Further guidance exists from the Association of Anaesthetists regarding postoperative recovery (Association of Anaesthetists 2013) and standards for monitoring during anaesthesia and recovery (Klein 2021).

Cardiac critical care

The most common postoperative care approach for patients who have undergone major cardiac surgery is to be admitted to a cardiac critical care unit directly after surgery. Nearly all patients are transferred from the operating theatre to the critical care unit, sedated and receiving mechanical ventilation via a tracheal tube. The approach to resuscitation in patients after cardiac surgery differs from standard resuscitation practice with a focus on correcting rhythm disturbances, later use of adrenaline and early re-sternotomy. Training for this procedure in the UK has been addressed by specific educational courses for over 20 years, such as CALS (Dunning 2006). This specialist approach is reflected in the UK national standards for cardiothoracic intensive care included in the *Guidelines for the Provision of Intensive Care Services* (FCIM/ICS 2022), which state that the 'resident team must be trained in Cardiac Surgery Advanced Life Support (CALS) and be capable of emergency chest re-opening 24/7'.

What we found

Recovery

Some 30 (3.4%) of all the 881 NAP7 cardiac arrests occurred in recovery and accounted for 22% of cardiac arrests in recovery areas, critical care units and wards.

Compared with the NAP7 Activity Survey, increasing age, male sex (53% vs 46%), higher ASA scores, higher surgical complexity, weekend or non-daytime procedure, urgent surgery and use of neuraxial anaesthesia with general anaesthesia or sedation were more prevalent in patients who developed cardiac arrest in recovery. Higher body mass index (BMI) and frailty were not. The surgical specialties of the patients are shown in Figure 39.1.

The main specialties that were overrepresented numerically among patients having cardiac arrest in recovery compared with the Activity Survey data were vascular surgery (13% vs 2.3%) and lower gastrointestinal (GI) surgery (10% vs 5.9%).

The panel-agreed causes of cardiac arrest are shown in Table 39.1. More than one cause could be assigned to each patient. On review of the assessment panel's comments for individual patients, several themes were apparent:

Figure 39.1 Surgical specialties of patients who had a cardiac arrest in recovery reported to NAP7. ENT, ear, nose and throat; GI, gastrointestinal.

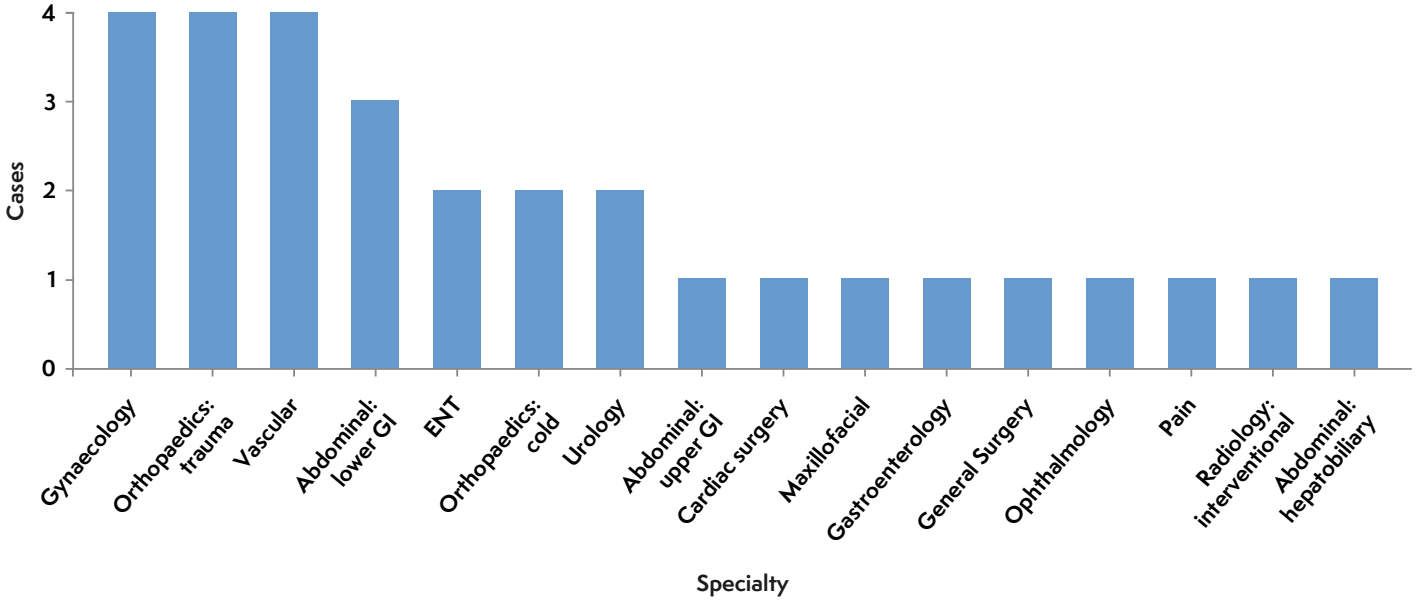


Table 39.1 Panel agreed causes of cardiac arrest in recovery

Cause of arrest	Patients (*n*)
Severe hypoxaemia	10
Bradyarrhythmia	6
Major haemorrhage	6
Drug error	5
Vagal outflow (eg pneumoperitoneum, oculocardiac reflex)	4
Cardiac ischaemia	2
Septic shock	2
Ventricular fibrillation	3
Residual anaesthesia	1
Isolated severe hypotension (central vasopressors considered/started)	1
Pulmonary embolism	1
Significant hyperkalaemia	1
Transurethral resection syndrome	1
Uncertain	4

- Inadequate monitoring – in 10 reports the panel judged that there could have been better monitoring of patients, including during transfer from theatre (3 patients), invasive arterial pressure monitoring (5 patients) and exhaled carbon dioxide monitoring during sedation (1 patient).
- Medication errors – in five patients there were errors with medicines including inadvertent cessation of vasopressor infusion (one patient), excess intravenous opioid (one patient), excessive intrathecal doses of opioid and or local anaesthetics (two patients) and excess dose of infiltrated local anaesthetic (one patient).
- Loss of patent airway – three patients had loss of a patent airway due to thyroid surgery haemorrhage, tracheostomy misplacement and, in a patient with obstructive sleep apnoea, during transfer to recovery.
- Post-extubation respiratory depression – four patients had severe hypoxaemia secondary to respiratory depression before cardiac arrest. In three of these patients, medication error and lack of monitoring between theatre and recovery were associated with cardiac arrest.
- Haemorrhage – five patients had major haemorrhage before cardiac arrest. The panel judged that there was a delay in recognition of the severity of haemorrhage in two patients.
- Hypotension – three patients were assessed as having hypotension as the primary cause of cardiac arrest. Two of these patients had septic shock.
- Vagal tone – three patients were thought to have severe bradycardia secondary to high vagal tone as a primary cause of cardiac arrest. These occurred after eye and gynaecological operations and the third after urinary catheterisation (all three survived).
- Pacemaker – a single patient had a cardiac arrest following an R on T pacing beat from a temporary external pacemaker. This event highlights the importance of checking pacemaker sensing function as well as pacemaker capture thresholds (see cardiac critical care below).
- Hyperkalaemia – one patient had severe hyperkalaemia that had been inadequately monitored and treated in the operating theatre prior to admission to recovery.

Outcomes of cardiac arrests in recovery were similar to those in the whole group, with an overall restoration of spontaneous circulation (ROSC) in 73% (75% in all NAP7 cardiac arrest cases). The assessment of care in reports of cardiac arrest occurring in recovery is shown in Table 39.2.

Table 39.2 NAP7 panel rating of care for cardiac arrest cases occurring in recovery

Period of care	Good, *n* (%)	Good and poor, *n* (%)	Poor, *n* (%)	Unclear, *n* (%)
Pre-cardiac arrest	7 (23)	9 (30)	8 (27)	6 (20)
During cardiac arrest	23 (77)	6 (20)	0 (0)	1 (3.3)
Post-cardiac arrest	21 (70)	4 (13)	1 (3.3)	4 (13)
Overall	7 (23)	16 (53)	1 (3.3)	6 (20)

In 17 (57%) reports relating to cardiac arrest in recovery, 6 of whom died, care before cardiac arrest was rated poor or good and poor: this compares with 32% in all cases reported to NAP7.

Factors associated with cardiac arrest in cases with poor or good and poor ratings of care before cardiac arrest in recovery included:

- lack of monitoring during transfer to recovery (five cases)
- lack of invasive blood pressure monitoring (four cases)
- excessive intrathecal drug dosing (three cases)
- excessive dosing of other drugs (two cases)
- interruption of vasopressor infusion (one case)
- delayed recognition of haemorrhage (one case)
- inadequate management of hyperkalaemia (one case)
- inadequate management of blood pressure (one case).

A middle-aged patient was extubated in theatre after major elective surgery and transferred to recovery without monitoring. Shortly after arrival in recovery, the patient had an asystolic cardiac arrest secondary to hypoxaemia from opioid-induced respiratory depression. The patient was resuscitated successfully and discharged home. The panel view was that deterioration had probably been missed during the transfer.

An older patient with multiple comorbidities had urgent out of hours abdominal surgery. The patient was extubated in the operating room and was transferred to recovery without monitoring. During the transfer, the patient had a respiratory (hypoxaemic) and subsequent pulseless electrical activity (PEA) cardiac arrest. The patient was successfully resuscitated and discharged home after a prolonged hospital stay. The panel were critical of the lack of monitoring and that deterioration had probably been missed during the transfer.

Critical care

The criteria for inclusion in NAP7 for patients having a cardiac arrest within critical care included (Chapter 6 Methods):

- Patients in critical care within 24 hours of the end of their procedure/handover to the critical care team.
- Patients in critical care having an interventional procedure in another location under the care of an anaesthetist (excludes diagnostic imaging) from first hands-on intervention, including transfer.
- Patients who were excluded were:
  - sedation or anaesthesia solely for critical care
  - procedures performed in the critical care unit (eg percutaneous tracheostomy)
  - any intrahospital or interhospital transfers originating in critical care.
- The Baseline Survey documented that 2.8% of critical care units did not have access to advanced airway equipment and in 4.5% a difficult airway trolley was not available (Chapter 9 Organisational survey).

Seventy-six cardiac arrests occurring in a critical care unit met the inclusion criteria and were reported to NAP7. Compared with the Activity Survey, patients having a cardiac arrest within critical care were more likely to be male (59% vs 46%), older, with higher ASA scores, more likely to be frail (clinical frailty score 5 or above, 53% vs 34%) and have a higher frequency of general anaesthesia or general anaesthesia plus neuraxial block. Procedures were more commonly at night and at weekends, were more often major or complex and more often of immediate and urgent priority. Surgical specialties that were represented more frequently in this group of cardiac arrest reports compared with the Activity Survey were cardiac surgery (33% vs 1%), lower GI surgery (24% vs 5.9%), vascular surgery (7.9% vs 2.3%) and cardiology electrophysiology (2.6% vs 0.7%) (Figure 39.2).

One-third of cardiac arrests in critical care units were in patients who had undergone cardiac surgery in the previous 24 hours and these are summarised separately below. There were too few cardiac arrests in other specialist critical care units, for example neurosurgical units, to describe other separate cohorts.

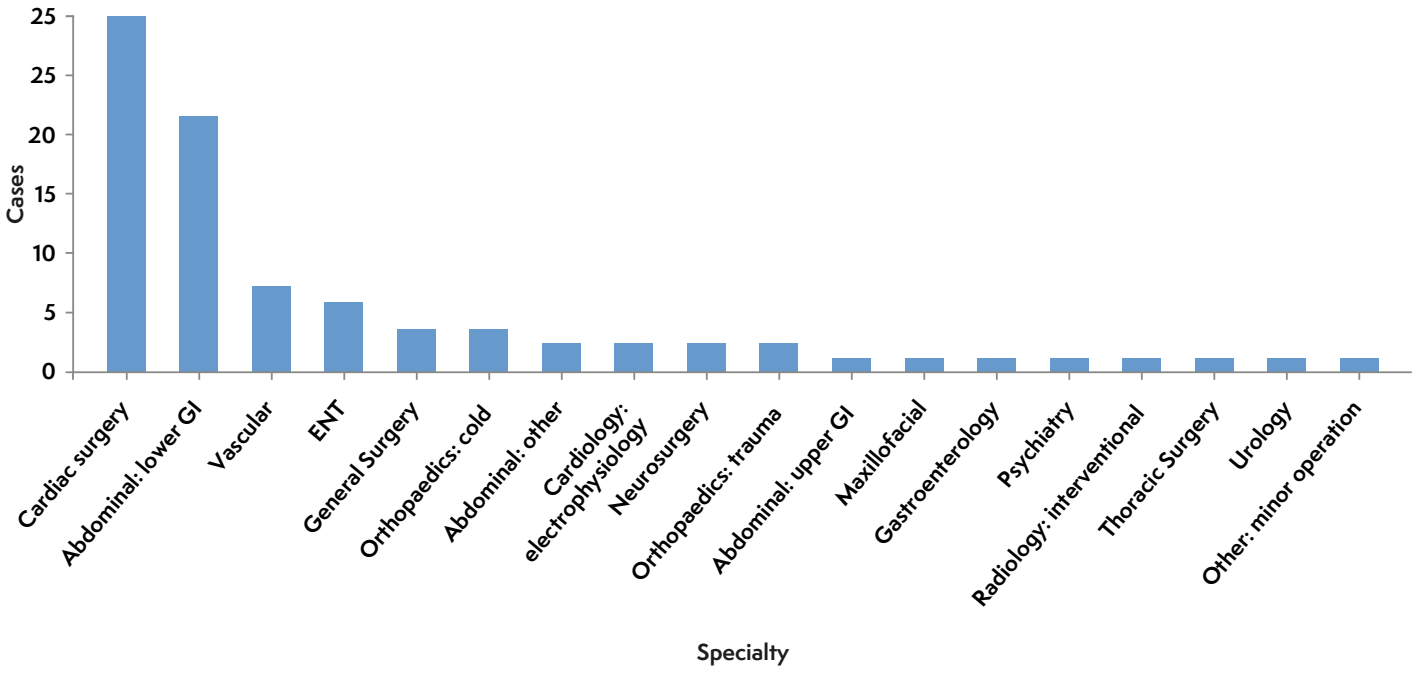
Non-cardiac surgical critical care

A total of 51 reports described cardiac arrests occurring in critical care units after non-cardiac surgery; 42 patients were ASA 3–5 (18 ASA 3, 18 ASA 4, 6 ASA 5).

The most common procedure was lower GI surgery, 18 patients, of whom 15 had undergone emergency laparotomy. 6 patients had undergone vascular surgery of whom 5 had aortic procedures (two elective). Overall, the urgency of operations was elective in 11 patients, expedited in 8 patients, urgent in 18 patients and immediate in 14 patients.

Some 26 of the 51 patients had preoperative risk scoring using five different risk scoring systems: 8 patients were considered low risk (< 5% estimated mortality risk), 7 as medium risk (5–10%)

Figure 39.2 Specialty for cardiac arrests occurring in critical care. ENT, ear, nose and throat.



and 10 as high risk (> 10%). Of the 18 patients having emergency laparotomy, 13 had preoperative individual risk scoring carried out.

A total of 49 patients had general anaesthesia (11 with additional epidural) and 2 patients had spinal anaesthesia. Anaesthesia using general anaesthesia and neuraxial block was more common in the patients who had a cardiac arrest in the intensive care unit (ICU) compared with the Activity Survey data (17% vs 4%).

Some 46 patients were reported to have had a handover to ICU staff from the theatre team (33 structured and 13 informal) with no handover for 1 patient and 4 unknown; 44 (62%) patients had been reviewed by an ICU doctor before cardiac arrest. In 33, this review was by a senior doctor (consultant or staff grade), 8 by a specialist trainee, 1 by a core trainee, 1 by an anaesthetic nurse practitioner and 1 unknown. At the time of cardiac arrest, 29 patients were intubated and ventilated (27 tracheal tube and 2 tracheostomy) and 22 patients were not (21 breathing though a natural airway and one via tracheostomy).

Cardiac arrest occurred at a median of 5.2 hours (mean 7.3 hours) after ICU admission; 32 cardiac arrests (63%) occurred at night (20.00–07.59).

The most common panel-agreed primary causes of cardiac arrest were:

- septic shock (12 patients)
- haemorrhage (5 patients)
- hypotension (4 patients)
- pulmonary embolism (3 patients)
- bradycardia (3 patients)
- hypoxaemia (3 patients)
- unclear (8 patients).

Three patients had a cardiac arrest after loss of airway leading to severe hypoxaemia. In two patients this was after unintentional tracheostomy decannulation and in one patient there was loss of airway after extubation following non-elective airway surgery.

Five (10%) cardiac arrests occurred during a medical intervention – three after drug administration and two after other interventions. Drug administrations that led directly to cardiac arrest included suxamethonium-induced hyperkalaemia, antibiotic induced anaphylaxis and hypotension secondary to anaesthetic induction drugs. The non-drug interventions causing cardiac arrest both resulted in ventricular fibrillation (VF), one induced by a guidewire during central venous catheter insertion and one induced by DC cardioversion.

Five (10%) patients had cardiac arrests associated with physical movement – two patients who had elective lower GI surgery managed with epidurals developed asystole (both recovered) and three patients with a tracheostomy had a cardiac arrest related to movement, two from hypoxia after unintended tracheostomy decannulation and one patient through likely vagally mediated asystole.

All 51 cardiac arrests were witnessed, and a cardiac arrest call was put out in 19 cases (37%). The initial cardiac rhythm was PEA in 36 patients, asystole in 9 patients, VF or pulseless ventricular tachycardia (pVT) in 5 patients and unknown in 1 patient.

The cardiac arrest was reported to have been managed according to ALS guidelines in 37 patients (73%), 5 with no guidelines and unknown in 7 reports. Echocardiography was used during cardiac arrest in nine patients (18%), which is the same as seen in all 881 NAP7 cardiac arrest reports (Chapter 15 Controversies).

A total of 32 (63%) of 51 patients died, 4 (8%) survived with severe harm and 15 (29%) with moderate harm; 13 of 18 patients who had a cardiac arrest after emergency laparotomy died. In 8 of these 13 patients, the panel judged that cardiac arrest was partially or wholly related to an inexorable illness-related process.

The assessment panel highlighted several themes that point to potential improvements in patient care including:

- Invasive monitoring – the panel identified four patients who may have benefited from invasive arterial blood pressure monitoring from earlier in their care. This is similar to that seen in patients who had cardiac arrests in recovery.
- Tracheostomy displacement – two patients had hypoxaemic cardiac arrest and poor outcomes related to airway loss related to patient movement.
- Tracheal extubation – a patient had a cardiac arrest after an out of hours planned extubation following emergency airway surgery.

A summary of the assessment panel's ratings of quality of care is shown in Table 39.3. These are very similar to assessments of the whole NAP7 cohort (Chapter 13 Reported case summary).

Table 39.3 NAP7 panel rating of care for cardiac arrest cases occurring in non-cardiac surgical critical care units

Period of care	Good, *n* (%)	Good and poor, *n* (%)	Poor, *n* (%)	Unclear, *n* (%)
Pre-cardiac arrest	22 (43)	11 (22)	2 (4)	16 (31)
During cardiac arrest	40 (78)	2 (4)	1 (2)	8 (16)
Post-cardiac arrest	33 (65)	2 (4)	0 (0)	14 (27)
Overall	22 (43)	14 (27)	0 (0)	15 (29)

In 13 of 51 case reports, the assessment panel rated pre-cardiac arrest care as 'poor' or 'good and poor': five of these patients died, two had severe harm and six moderate harm. The most common surgical specialties were lower GI (all laparotomy), ear, nose and throat and vascular surgery, with six having had elective surgery. The most common issues noted by the panel from these 13 case reports included:

- delays in care – procedures or management of shock (five cases)
- sepsis (three cases)
- inadequate monitoring in theatre or during transfer to ICU (three cases)
- loss of airway (three cases)
- inadequate follow-up of abnormal preoperative investigations (two cases, abnormal ECG in one case, abnormal tryptase after potential drug reaction in another case).

Before admission for elective minor surgery with a general anaesthetic a preadmission ECG showed left axis deviation and suggested significant left ventricular hypertrophy. No further cardiac investigations were carried out. At induction of anaesthesia the patient became haemodynamically unstable and surgery was abandoned. The patient was transferred to a critical care unit where they had a PEA cardiac arrest followed by successful resuscitation. Further investigations showed a significant cardiomyopathy. The patient required a prolonged critical care unit and hospital stay before discharge home.

Cardiac surgical critical care

Some 25 reports of cardiac arrest in patients in a cardiac surgical critical care unit were received by NAP7. This accounts for the largest single surgical group of patients and one-third of all critical care cardiac arrests cases reported to NAP7.

Surgery was for coronary artery bypass grafting (CABG) in 10 patients (1 with additional valve surgery), valve surgery only in 8 patients and surgery involving the ascending or arch of the aorta in 7 patients. All except one patient had cardiopulmonary bypass and one patient had off-pump CABG. Surgery for nine patients was elective, six expedited, seven urgent and three immediate.

Of the 18 patients with Euroscore reported, 13 had a predicted mortality of less than 5% and 3 patients had a predicted mortality greater than 10%.

Cardiac arrest occurred a median of 3.2 hours (mean 5.3 hours) after surgery. Initial rhythms were PEA (15 patients), VF or pVT (four patients), asystole (three patients) and the rhythm was unclear in one patient. At the time of cardiac arrest, 21 patients were intubated and ventilated and 4 had been extubated.

The main cause of cardiac arrest in 11 patients was haemorrhage (5 of these also having cardiac tamponade). Three patients developed ventricular standstill because of new conduction delays, without back-up temporary pacing (one aortic valve replacement, two CABG, one root replacement). Other causes were coronary artery bypass graft failure (three patients), right ventricular failure (two patients), VF during ventricular pacing (two patients) and tension pneumothorax, transient cardiac ischaemia, biventricular failure and VF from unknown cause (each one patient).

Of the 25 cardiac arrests, 23 were managed according to CALS guidelines. Fifteen patients underwent re-sternotomy as part of resuscitation, and two patients already had an open sternum in ICU. Emergency re-sternotomy was carried out by a surgical registrar (10 patients), consultant surgeon (4 patients) and consultant in anaesthesia and intensive care medicine (1 patient). The median time to re-sternotomy was 5 minutes, with a reported range of 2–60 minutes; 12 of 15 patients with an initial PEA cardiac arrest underwent re-sternotomy. Of the 15 patients who underwent emergency re-sternotomy, 3 died. Six patients underwent echocardiography during resuscitation.

Of the 25 patients who had a cardiac arrest, 21 survived the event. Among four patients who died, two had a rupture of the heart that could not be repaired, one had rupture of the aorta and one had cardiogenic shock after surgery for infective endocarditis and had been transferred to ICU with the sternum open.

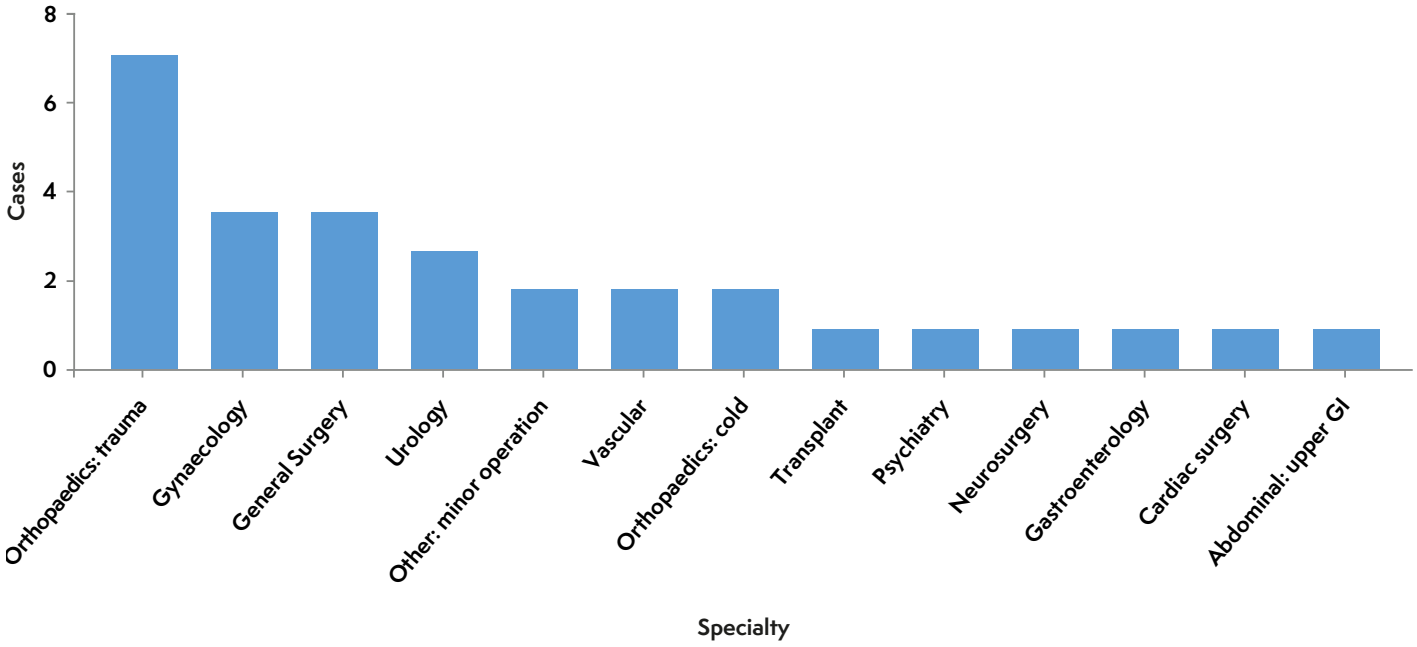
The panel ratings of quality of care were very positive. In only 1 of 25 reports was care before cardiac arrest judged as poor and good overall care was judged good in 23 cases with one good and poor and one unclear.

A patient started bleeding into chest drains out of hours within an hour of arriving in the ICU following uncomplicated elective cardiac surgery. The patient's systolic blood pressure fell to less than 50 mmHg, a cardiac arrest call was made and CPR was started. The PEA cardiac arrest was managed using the CALS algorithm and re-sternotomy was carried out by a cardiac surgery registrar within five minutes. Surgical bleeding was identified and repaired. ROSC was obtained in less than 10 minutes. The patient recovered and was discharged home after a delayed discharge.

Ward cardiac arrests

A total of 31 (3.4%) of 881 cardiac arrests reported to NAP7 occurred in ward areas. Ward cardiac arrests occurred twice as frequently between 18.00 and 06.00 compared with the daytime (67% vs 33%). The surgical specialties of patients who had a ward cardiac arrest are shown in Figure 39.3.

Figure 39.3 The surgical specialty of ward perioperative cardiac arrests. GI, gastrointestinal.



The surgical specialties overrepresented in ward cardiac arrest patients compared with the Activity Survey data were vascular surgery (6.5% vs 2.3%) and orthopaedics–trauma (26% vs 11%). It is notable that none of the patients who had a ward cardiac arrest had undergone lower GI surgery.

Compared with other patients reported to NAP7 who had a cardiac arrest, those who had a cardiac arrest on the ward were demographically similar with few major differences in distributions of age, sex, ASA, BMI, ethnicity or frailty. Anaesthetic technique in this cohort more often included neuraxial anaesthesia and or sedation (32% vs 9%) but this probably relates to the surgical specialties involved. The panel-agreed causes of cardiac arrest agreed by the assessment panel are listed in Table 39.4.

From the panel's comments, several themes were apparent:

- Wrong location of care – in 12 (39%) cases, the assessors judged that the patient should have received a higher level of care, such as theatre recovery or critical care. Of these patients, four had undergone orthopaedic procedures (three fractures, one revision joint replacement). In one patient, there was recognition that the patient should have been in a higher care area but the patient was stepped down early from critical care because of inadequate capacity. Of these 11 patients, 6 died.
- Neuraxial anaesthesia and trauma surgery – in 10 (32%) cases the patients had received anaesthesia consisting of only neuraxial or neuraxial plus sedation compared with 8.7% of NAP7 Activity Survey and 7.3% of all other cardiac arrests reported to NAP7. Eight of the patients had undergone non-elective orthopaedic surgery for fractures and six of these patients died.
- Medication – in five patients medication issues were judged contributory to cardiac arrest. These were administration of excessive intrathecal or intravenous drugs (three and one patient, respectively) and failure to administer perioperative steroids leading to an Addisonian crisis (one patient).
- Procedure in inappropriate location – one patient had a cardiac arrest during daycare cardioversion in a high-risk patient, which was carried out in a ward setting.

For the 31 ward cardiac arrests reported to NAP7:

- The initial cardiac arrest rhythm was asystole in 8 patients (26%), bradycardia in 1 patient (3.2%), PEA in 13 patients (42%), ventricular fibrillation in 3 patients (9.7%) and unknown in 6 patients (19%).
- Outcomes in this cohort were less good than for all other perioperative cardiac arrests, with 10 (32%) surviving to hospital discharge compared with 44% for all other perioperative cardiac arrests, and 9.7% (three patients) and 17% of patients still admitted at the time of reporting.

Table 39.4 Panel agreed causes of ward perioperative cardiac arrest. Number of causes more than number of cases as panel could assign more than one cause.

Panel agreed cause	Cases (*n*=35)	
	(*n*)	(%)
Major haemorrhage	4	11.4
Cardiac ischaemia	3	8.6
Severe hypoxaemia	3	8.6
Isolated severe hypotension (central vasopressors considered/started)	2	5.7
Pulmonary embolism	2	5.7
Septic shock	2	5.7
Addisonian crisis	1	2.9
Aspiration of gastric contents	1	2.9
Bradyarrhythmia	1	2.9
Cardiac tamponade	1	2.9
Complete heart block	1	2.9
DC cardioversion	1	2.9
Drug error	1	2.9
Intracranial haemorrhage (including subarachnoid haemorrhage)	1	2.9
New significant acidosis /acidaemia	1	2.9
Opioid overdose	1	2.9
Seizure	1	2.9
Stroke	1	2.9
Vagal outflow (eg pneumoperitoneum, oculocardiac reflex)	1	2.9
Ventricular fibrillation	1	2.9
Airway obstruction in patient with sleep apnoea		2.9
Other	4	11.4

The assessment panel's rating of care is shown in Table 39.5. Care before cardiac arrest in this group was, compared with all patients reported to NAP7, less often rated as good (19% vs 48%) and more often rated as poor (26% vs 11%). Overall care was less often rated as good (16% vs 53%) and more often rated as poor (16% vs 2%).

Table 39.5 Panel rating of care in patients who has a ward cardiac arrest

Period of care	Good, *n* (%)	Good and poor, *n* (%)	Poor, *n* (%)	Unclear, *n* (%)
Pre-cardiac arrest	6 (19)	7 (23)	8 (26)	10 (32)
During cardiac arrest	13 (42)	3 (9.7)	3 (9.7)	12 (39)
Post-cardiac arrest	12 (41)	2 (6.9)	4 (14)	11 (38)
Overall	5 (16)	11 (35)	5 (16)	10 (32)

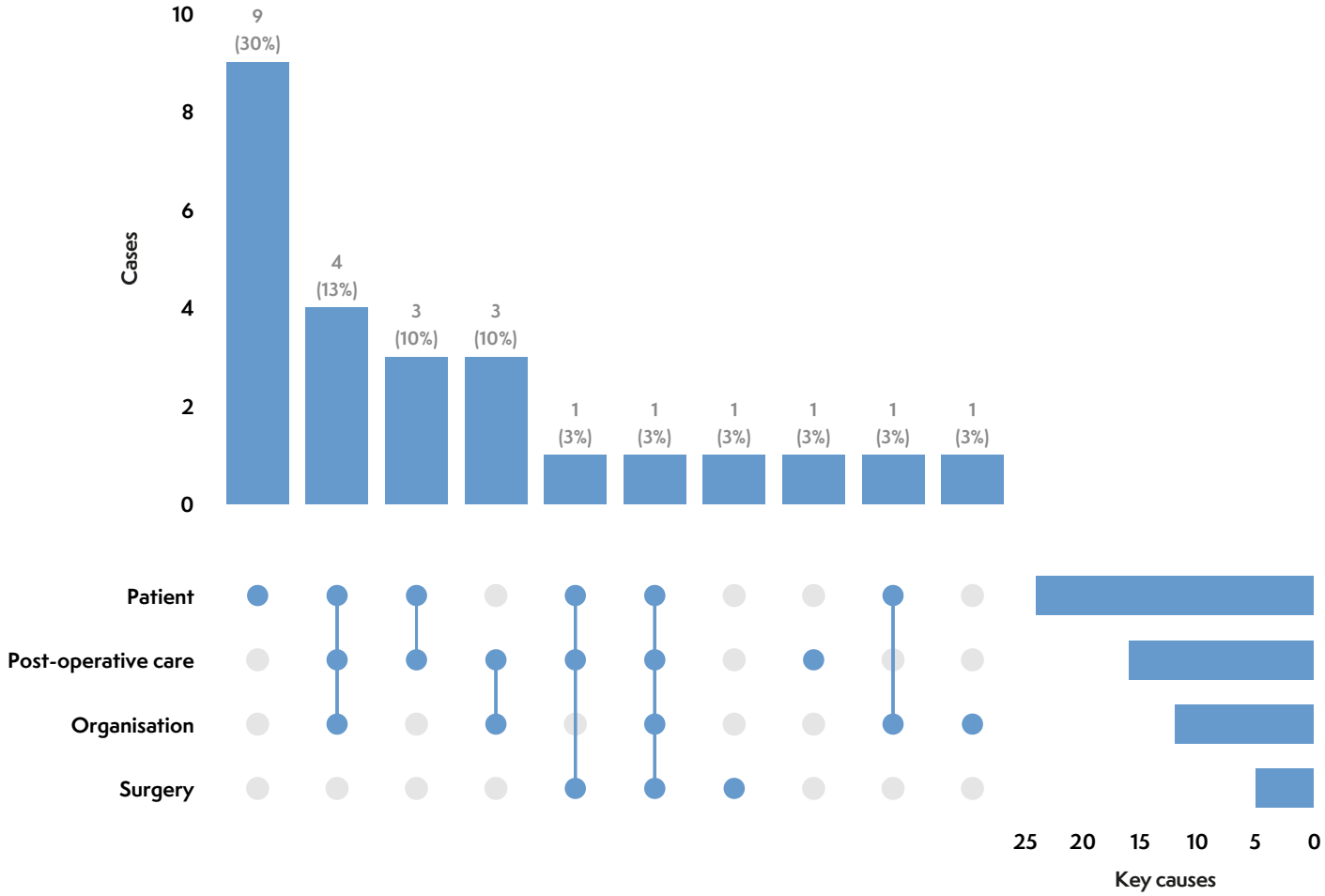
Of the 15 patients (49%) with care before cardiac arrest rated as poor or good and poor, 9 patients died. The most common factors noted in these reports were the patient being in the wrong location for care (11 patients, 73%), use of spinal anaesthesia (6 patients, 40%) and orthopaedic surgery (4 patients, 27%). All four orthopaedic patients in this group had a spinal as part of their anaesthetic technique.

After patient and postoperative care factors, organisational factors were considered as the main contributing factor for the cardiac arrest (Figure 39.4)

Only 2 of the 31 patients who had a ward cardiac arrest had a preoperative individual risk assessment, despite 71% of patients being categorised as ASA 3–5. None of the 11 patients whose pre-arrest care was rated 'poor' or 'good and poor' and were considered to be in the wrong location of care, had undergone a preoperative individualised risk assessment.

An older patient with significant complex cardiac comorbidities underwent urgent surgery for a hip fracture. No individualised risk assessment was carried out and the patient was not reviewed by the orthogeriatric team as it was a weekend. Surgery was carried out under spinal anaesthesia and after a short period in recovery, the patient was discharged to a surgical ward with stable observations. That evening, the patient became tachycardic and after review was given a dose of a beta blocker. Approximately an hour later, the patient was found in PEA cardiac arrest and could not be resuscitated.

Figure 39.4 Panel agreed causes of perioperative cardiac arrests that occurred on wards. Top 10 causes shown.



An older patient with severe heart disease had uneventful surgery with a spinal anaesthetic. Owing to capacity issues, the patient was discharged to an outlying ward that did not usually care for complex postoperative patients. The patient's condition deteriorated on the ward and the patient had a cardiac arrest from which resuscitation was unsuccessful. There were delays in summoning the cardiac arrest team and problems with accessing equipment and drugs during the resuscitation attempt.

Discussion

Recovery

The largest area for potential improvement is in the use of patient monitoring. There is evidence that minimum monitoring standards for patients are not always being met. The 2021 Association of Anaesthetists Recommendations for Standards of Monitoring During Anaesthesia and Recovery (Klein 2021) states:

> *Transfer requires minimum monitoring of ECG, SpO2 [peripheral oxygen saturation] and NIBP [non-invasive blood pressure]. If an airway device remains in place capnography should be used during the transfer of anaesthetised or sedated patients, including from the operating theatre to the PACU [post-anaesthetic care unit].*

In 10 (one-third) of the cardiac arrests, the assessment panel judged that there should have been better patient monitoring to detect and treat deterioration before the cardiac arrest occurred, including in theatre and during transfer from theatre to the recovery area. Free-text comments in NAP7 reports included that it was local policy or usual practice not to use monitoring during the transfer between theatre and recovery – this practice should no longer be happening in the view of the panel.

Lack of invasive arterial pressure monitoring in theatre and recovery was judged to be a contributing factor in four cardiac arrests. There are no nationally agreed criteria for the use of invasive blood pressure monitoring in perioperative care.

Critical care

First, it is likely that not all cardiac arrests occurring within 24 hours of the end of their procedure/handover to the critical care team were reported to NAP7 compared with those that occurred during a procedure in the presence of an anaesthetist. The cases reported do, however, highlight important areas of postoperative care. A UK-wide prospective observational study of critical

illness-related cardiac arrest in patients cared for in critical care units is currently under way and should provide further information about this patient group (Darnell 2022).

The findings are generally positive and have highlighted care issues that have been recognised before. About 90% of patients who had a cardiac arrest in ICU had been reviewed by a doctor before they arrested and 89% of these reviews were by a consultant, specialist, associate specialist and specialty-grade doctor or specialty trainee year 5 (ST5) or above. The assessment panel rated pre-cardiac arrest as 'poor' in only two reports.

The NAP7 panel noted two delays in procedure and three delays in pre-arrest management. While it is important not to delay procedures, this can sometimes be logistically challenging. Some delays in care may be secondary to a delay in recognition of a problem, usually because of inadequate monitoring or staff availability or training.

The issue of inadequate monitoring in theatre or during transfer to critical care was also noted to be a factor in patients who had cardiac arrest in recovery. Similar recommendations of adherence to national guidance on mandatory monitoring during patient transfer and a lower threshold for invasive blood pressure monitoring are also likely to lead to a reduction in cardiac arrests within critical care. The NAP7 case reports have highlighted the potential serious consequences of inadequate follow-up of preoperative test results, in particular to allergy testing (NAP6; Kemp 2018) and abnormal ECGs.

Three patients developed cardiac arrest after loss of the airway, including two tracheostomy displacements. A tracheostomy may be dislodged when a patient with a tracheostomy is moved; the airway needs to be specifically monitored by a dedicated member of staff. Staff must have access to standard difficult airway equipment in any clinical area where this may happen and should be trained in its use. NAP4 recommended the need for every ICU to have immediate access to a difficult airway trolley (Cook 2011). The same difficult airway equipment should be available in different clinical areas of hospitals.

Extubation guidelines that include a risk assessment should be implemented in all critical care areas to minimise high-risk extubation being carried out in the wrong location by staff with insufficient experience. The need for extubation algorithms in intensive care units was highlighted in NAP4 (Cook 2011).

Cardiac surgical critical care

The quality of care was rated as good in a high proportion of reports, with successful resuscitation based on the widespread adoption of CALS resuscitation protocols. Early re-sternotomy was common and usually performed by a surgical ST3+ doctor. In only one report was re-sternotomy undertaken by a non-surgeon, and this patient survived. Five cardiac arrests were associated with either failure to use or complications (ventricular fibrillation during pacing) of temporary epicardial pacemakers.

The use of temporary epicardial pacing is common after cardiac surgery – 17.5% in a recent report of over 11,000 patients undergoing cardiac surgery (Cote 2020). Multiple risk factors for postoperative conduction problems have been reported; for example, aortic valve replacement is associated with an approximately 6% need for postoperative permanent pacemaker implantation. The safe use of epicardial pacing systems requires daily checks of both pacing capture and sensing thresholds.

Ward cardiac arrests

It is likely that some postoperative ward cardiac arrests were not captured by NAP7 reports and many will have happened beyond the 24-hour NAP7 inclusion period. In an analysis of the American College of Surgeons National Quality Improvement Program (2005–2010), among a total of 6382 non-trauma surgical patients undergoing cardiopulmonary resuscitation within 30 days of surgery, 86% occurred postoperatively, of which 50% occurred more than 5 days after surgery (Kazaure 2013).

In NAP7, orthopaedic trauma had twice as many reported ward cardiac arrests compared with other surgical specialties. Organisational factors were much more commonly associated with postoperative ward cardiac arrest when compared with all other perioperative cardiac arrest locations.

It is probable that the high incidence of spinal anaesthesia (with or without sedation) is related to the anaesthetist's judgement of a high risk from general anaesthesia and the high number of orthopaedic trauma patients.

The absence of lower GI surgery patients in the ward cardiac arrest cohort is perhaps a reflection of the success of National Emergency Laparotomy Audit in successfully improving the care of patients undergoing emergency laparotomy. In particular, the use of risk scores to ensure that the highest risk patients are referred and admitted to critical care postoperatively.

There was a near complete absence of individual patient risk assessments in patients who subsequently had a ward cardiac arrest despite multiple national guidelines and standards that have recommended the following:

- *General Provision of Anaesthetic Services* Chapter 2, 4.2 (RCoA 2023): 'As a minimum, all ASA 3–5 patients and those undergoing high-risk surgery should have their expected risk of morbidity and mortality estimated and documented prior to an intervention, with adjustments made in accordance with national guidelines in planning the urgency of care, seniority of staff involved and postoperative care.'
- With specific reference to non-elective orthopaedic surgery the *Guideline for the Management of Hip Fractures* (Griffiths 2021) states, 'the Working Party recommends that hospitals assess all hip fracture patients' and that 'management should continue to involve carefully administered, (invasively) monitored general or spinal anaesthesia, which aims to

maintain coronary and cerebral perfusion pressures, with possible short-term admission to a higher-level care unit postoperatively'.

- Guidelines have been published for the implementation of enhanced care (FCIM/CPOC 2020). Current capacity to provide enough care to meet the demands of fully risk assessed care is likely to be inadequate. Enhanced care provides an alternative to (more resource heavy) critical care and is likely to be sufficient for most patients who are currently being placed in ward beds inappropriately.
- Centre for Perioperative Care (CPOC) guidance on establishing and delivering enhanced perioperative care (FCIM/CPOC 2020) uses inclusion criteria that would include the patients the assessment panel concluded were in the wrong location of care: The patient population most likely to benefit from enhanced perioperative care can be considered in terms of:
  - having a predicted risk of mortality within 30 days of surgery of more than 1%, using a validated risk assessment tool based on a minimum of age, complexity and urgency of the surgical procedure and patient factors such as comorbidities, fitness and frailty
  - undergoing specific surgical interventions; for example, free-flap surgery requiring enhanced levels of monitoring and therapy input to support early mobilisation
  - requiring enhanced monitoring; for example, short term invasive monitoring to facilitate perioperative haemodynamic management or management of epidural-related hypotension
  - requiring additional medical support; for example, correction of an acute arrhythmia, or treatment of difficult to manage pain
  - requiring safe management of existing comorbidities; for example, obstructive sleep apnoea on continuous positive airway pressure.

Recommendations: recovery

Institutional

- There should be a low threshold for continuous invasive arterial blood pressure monitoring in theatre. Implementation should be supported with updated national guidelines, particularly for monitoring of invasive arterial pressure.
- The 2021 Association of Anaesthetists recommendation for mandatory monitoring of patients being transferred from the operating room to recovery or the critical care unit should be implemented universally and with high priority (Klein 2021).

Recommendations: critical care

National

- There should be a low threshold for continuous invasive arterial blood pressure monitoring in theatre. Implementation should be supported with updated national guidelines, particularly for monitoring of invasive arterial pressure.
- The 2021 Association of Anaesthetists recommendation for mandatory monitoring of patients being transferred from the operating room to recovery or the critical care unit should be implemented universally and with high priority (Klein 2021).
- Extubation guidelines for critical care should be introduced in all ICUs. Guidelines should include risk evaluation and minimum staff and equipment. Staff involved in extubation must be trained and familiar with guidelines.

Institutional

- Emergency airway equipment should be standardised across all patient care areas, and staff must be trained in its use.
- A staff member should be assigned to ensure airway security whenever a patient is moved.

Research

- Research is required on the best method for securing tracheostomies.

Recommendations: cardiac surgical critical care

Institutional

- Cardiothoracic intensive care units should follow the Guidelines for the Provision of Intensive Care Services (FICM/ICS 2022) concerning the implementation of CALS-based resuscitation in all units.
- All cardiac surgery services should have standard operating procedures for the indications, setup and daily testing of temporary epicardial pacemaker systems that includes capture and sensing thresholds, and should ensure that resident staff are trained in their use.

Recommendations: ward cardiac arrests

- There should be an individual risk assessment of all patients both before and after a procedure to ensure that they receive the correct level of postoperative care.
- Risk assessment-based postoperative care pathway should be provided for all patients. This includes providing perioperative care as described by CPOC (2021).
- All hospitals need to review their provision of enhanced perioperative care and put in place care pathways that meet national guidance.

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