37 Cardiac arrest during cardiology procedures requiring anaesthesia


Seema Agarwal


Richard Armstrong


Simon Finney


Gudrun Kunst

Key findings

- The Seventh National Audit Project (NAP7) Baseline Survey indicates that approximately one-third of UK hospitals offer primary percutaneous coronary intervention services.
- Although interventional cardiology and electrophysiology represent only 1% of anaesthetic activity in the NAP7 Activity Survey, cardiology was ranked fifth in the prevalence of cardiac arrests, accounting for 54 (6.1%) of 881 all reported cardiac arrests. Of these cases 44 (81%) occurred in the catheter laboratory or a pacing room. The majority (84%) occurred during a procedure.
- A consultant or post-certificate of completion of training (CCT) fellow was present at the start of anaesthesia intervention in 61% and 7.5% of cases respectively; overall this was fewer than for non-cardiological procedures (88% and 0.5%, respectively).
- Slightly more than half (52%) of the cases reported died.
- The most common cause of cardiac arrest was judged to be cardiac ischaemia. Common themes in case reviews were cardiogenic shock, transcatheter aortic valve implantation (TAVI), late involvement of anaesthesia and poor communication.
- Of the 23 patients who died, it was considered that, in 10, the cardiac arrest was part of an inexorable process and in 6 partially so.
- Care was generally judged good (176 assessments) rather than good and poor (14) or poor (7). Nevertheless, 14 (26%) patients were judged to have had poor care at some point and half of these patients died.
- Rates of extracorporeal cardiopulmonary resuscitation were low, occurring in nine cases (1.1% of the total adult NAP7 cases and 16.7% of cardiological cardiac arrests).

What we already know

Several groups of patients will receive care from anaesthetists in the catheter laboratory. These include:

- Patients requiring primary coronary intervention as an emergency who also require anaesthetic support for sedation and/or the treatment of cardiogenic shock.
- Elective patients in whom anaesthetic involvement was planned to facilitate the procedure. These include those having coronary angioplasty but are more usually those having treatment for arrhythmias, valvular abnormalities (eg aortic stenosis and mitral regurgitation) or congenital defects such as an atrial septal defect.
- Elective patients, with no planned anaesthetic involvement, but who then develop major complications such as cardiac tamponade.

Percutaneous coronary intervention and cardiogenic shock

Almost 10% of patients who have a myocardial infarction will develop cardiogenic shock and approximately 50% of these patients will not survive to hospital discharge (Samsky 2021). The only treatment that has demonstrated efficacy in cardiogenic shock is emergency revascularisation after a myocardial infarction, through percutaneous coronary intervention (PCI) or bypass surgery. We also know that these patients who present for urgent or emergent care represent a high-risk cohort. Cardiogenic shock centres with 24/7 capability for primary percutaneous coronary intervention, mechanical circulatory support and specialist cardiac critical care have been proposed as part of a framework to improve care and outcomes (Intensive Care Society 2022).

While cardiac arrest during PCI is relatively common (approximately 10%), only a very small minority will have a protracted cardiac arrest episode during the procedure that results in death. Recent evidence has demonstrated that male sex, pre-existing cerebrovascular disease, chronic kidney disease

and disease of the left main stem or left anterior descending artery are independent predictors for cardiac arrest (Kumar 2021).

Dunning and colleagues have recently published guidelines, produced in collaboration with numerous British societies, for the management of cardiac arrest in the catheter laboratory (Dunning 2022). It is interesting to note that while there is a section dedicated to surgical support there is not one for anaesthetic support. The anaesthetist is mentioned only when intubation, mechanical ventilation and general anaesthesia are required. There are, however, detailed descriptions of management tools for the arrest situation aimed at improving outcome, including guidance for the use of medications, echocardiography and adjuncts. In particular, they discuss team training and recommend that catheter laboratory-specific training should be performed in every unit.

The authors also note that both the American Heart Association and the European Resuscitation Council recommend the use of extracorporeal membrane oxygenation (ECMO) in cardiac arrest. Extracorporeal cardiopulmonary resuscitation (eCPR) involves the use of extracorporeal membrane oxygenation, which helps to maintain organ perfusion while investigations and treatment for the primary cause of the cardiac arrest are being provided. Recent studies have shown that refractory in-hospital cardiac arrests treated with eCPR have a higher survival rate to discharge and better one-year survival than those who receive conventional treatment (Low 2023). Extracorporeal membrane oxygenation, and thus eCPR, is not available in all hospitals and is only used in a few specialist tertiary centres. NHS England has stated it will not routinely commission ECMO for adults with cardiac failure (NHSE 2016).

Elective procedures: transcatheter aortic valve implantation, mitral intervention and arrythmias

In 2016, there were 3,250 TAVIs performed in the UK (Ludman 2019). While these interventions used to be performed with general anaesthesia, over the past five years there has been a switch to performing them with sedation, often given without an anaesthetist present. The UK TAVI trial enrolled 450 participants who had a TAVI performed, of which 313 were carried out with sedation. (UK TAVI Trial Investigators 2022). This trial also found that TAVI is not inferior to surgery in patients 70 years of age or over. The quoted incidence of cardiac arrests during TAVI procedures is less than 1%; causes include cardiac tamponade and coronary artery occlusion by a displaced native or bioprosthetic aortic valve leaflet.

Mitral valve lesions are also routinely corrected in the catheter laboratory of specialised centres. These procedures involving the use of a device to approximate the leaflets and therefore reduce mitral regurgitation (transcatheter mitral edge-to-edge repair) and are relatively new when compared with TAVI. The COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients With Functional Mitral Regurgitation) trial found that among patients with heart failure and moderate-to-severe or severe secondary mitral regurgitation who remained symptomatic despite the use of maximal doses of guideline-directed medical therapy, transcatheter mitral-valve repair resulted in a lower rate of hospitalisation for heart failure and lower all-cause mortality within 24 months of follow-up than medical therapy alone (Stone 2018). Rates of cardiac arrest during transcatheter mitral-valve repair are quoted as between 0.8 and 1.4%. (Schnitzler 2021).

Arrhythmias are also treated in the catheter laboratory with ablation of accessory pathways. These may be performed with general anaesthetic or sedation, without an anaesthetist present. The rate of cardiac arrest is small (less than 1%; Steinbeck 2018).

What we found

Baseline Survey

In the NAP7 Baseline Survey, 61 (31%) of 197 responding Local Coordinators indicated that their hospitals offer 24-hour access to primary PCI services (Chapter 9 Organisational survey) There were 45 'heart attack centres' included in NAP7, which represented 24% of the hospitals which deliver adult anaesthesia.

Extracorporeal membrane oxygenation and/or eCPR services are offered by 18 (9%), 13 of which were centres treating adults. Of the 27 (14%) hospital sites that reported being cardiac surgery centres, 15 (56%) of them offered ECMO or eCPR.

Activity Survey

The NAP7 Activity Survey reported 217 cardiological cases that involved anaesthesia – suggesting that approximately 24,000 occur in the UK each year. Interventional cardiology (0.44%) and electrophysiology (0.55%) collectively accounted for 1% of anaesthetic activity in the NAP7 Activity Survey.

Case review

There were 54 cardiac arrests reported to NAP7 involving patients undergoing cardiological procedures, accounting for 6.1% of 881 cardiac arrests reported to NAP7. Therefore the estimated of incidence of cardiac arrests in this group of patients is 1 in 450 or 0.22% (95% confidence interval, CI, 0.17–0.29%). Cardiac arrests in patients having cardiological interventions were overrepresented approximately six-fold relative to the number of cases performed.

Most patients were male (70%), over 66 years (68%), ASA 3–5 (89%), undergoing urgent or immediate (59%), minor or intermediate procedures (66%) with sedation (22%) or general anaesthesia (65%).

Cases compared with the Activity Survey

Patients who had a cardiac arrest, when compared to the cohort of patients undergoing cardiological care in the Activity Survey, were older (> 75 years, 40% vs 21%), more likely to be highly

comorbid or unwell (ASA 4, 41% vs 14%, ASA 5 13% vs 0.5%); undergoing emergency care (immediate 39% vs 6.2%, urgent 20% vs 11%) and receiving care out of hours (weekend 15% vs 2.5%, non-working hours 20% vs 8.7%). The majority of patients who had a cardiac arrest during a cardiological procedure were white (88% vs 74%) but there was a disproportionately high number of Asian patients in the cardiac arrest cohort (17% vs 3.7%). Sex (70% vs 65% were male), body mass index (BMI) distribution and frailty differed little between groups.

Cases compared with other cardiac arrests reported to NAP7

Cardiology patients who had a cardiac arrest were, compared with the other 827 perioperative cardiac arrest patients reported to NAP7, more often male (70% vs 55%), somewhat more likely to be over 75 years (40% vs 23%), more likely to be comorbid or unwell (ASA 4–5, 54% vs 35%), Distribution of BMI and frailty did not differ notably between the groups.

DNACPR recommendations were uncommon, being present in only two patients (3.8%) compared with 5.2% of all other patients who had a cardiac arrest.

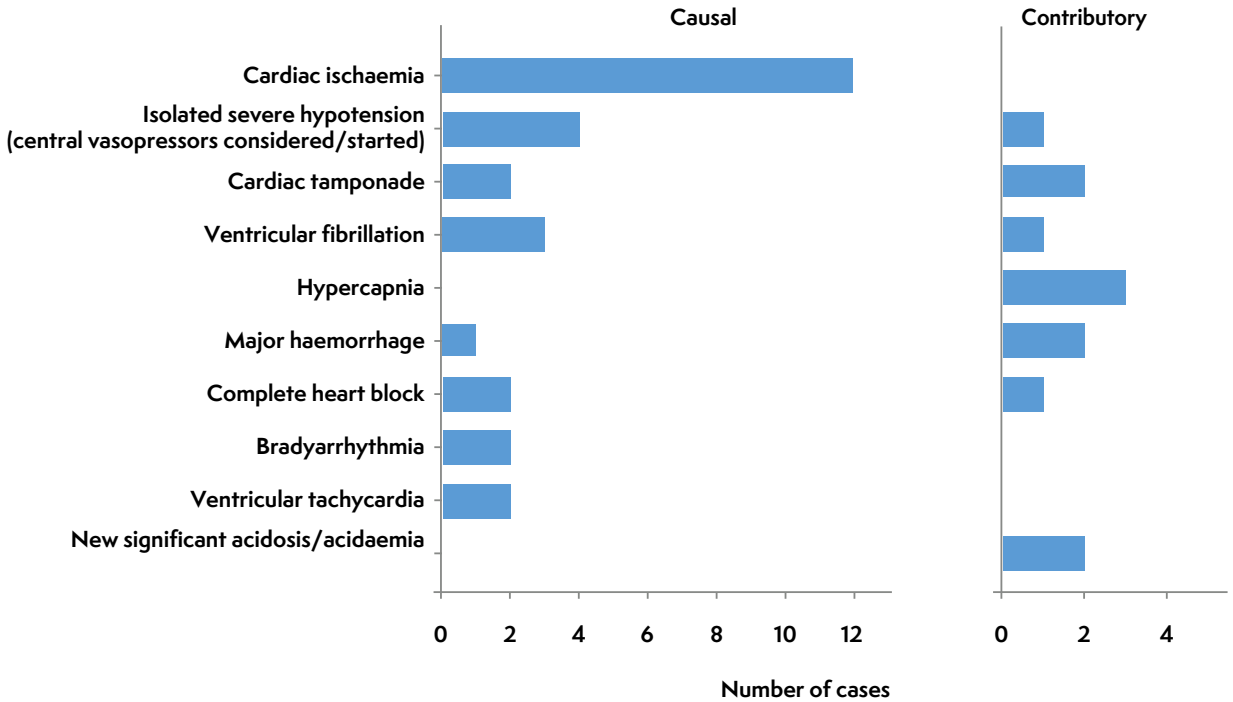
Unexpected events were predominantly cardiac including cardiac ischaemia, isolated hypotension, arrythmias and cardiac tamponade (Figure 37.1)

Cardiac arrests occurred commonly in hours (09.00–18.00, 72%) but less so than in other specialities (63%). Cardiac arrests most commonly occurred during the procedure (84%) and in the cardiac intervention suite (75%).

Initial rhythm of cardiac arrest was most commonly pulseless electrical activity (PEA; 56%) or bradycardia/asystole (28%), similar to other predominantly surgical patients in the NAP7 database (PEA 52%, bradycardia/asystole 30%). A shockable rhythm was the presenting rhythm in 16% and patients were defibrillated at some point in 26% of cases (vs 12% and 17%, respectively, of non-cardiology cases). Duration of resuscitation was often longer than in non-cardiac cases (< 10 minutes 46% vs 67%, 10–20 minutes 20% vs 13% and > 1 hour 11% vs 3.7%). Rates of eCPR were low; there were three cardiology cases in whom it was instituted: two who had cardiogenic shock during the time of angiography and one who had a cardiac arrest during a pacemaker change. Both of the patients who were undergoing angiographic intervention died. The patient having a pacemaker change survived. In another case, eCPR was considered but not available.

Survival from the initial arrest was lower than other patients reported to NAP7 (61% vs 76%). Overall hospital outcome was also poorer (48% vs 61% alive at the time of reporting).

Figure 37.1 Unexpected events during cardiology cases reported to NAP7



A team debrief was conducted in 37% of cases overall: in 30% where patients survived initial resuscitation and in 57% of cases where patients died.

Panel review

The main causes of the perioperative cardiac arrests in cardiology patients as agreed by the panel were predominantly primary cardiac causes including myocardial ischaemia (35%) and ventricular fibrillation (10%). Other arrythmias accounted for almost 20% of arrests (bradyarrhythmia 7%, ventricular tachycardia 7%, complete heart block 5.6%). Other rarer causes included cardiac tamponade and septic shock.

The key causes contributing to the cardiac arrest were judged to be patient related in 94% of cases, procedural in 41%, organisational in 13% and anaesthesia related in 9% (Figure 37.2). Of the 23 patients that died it was considered that for 10 this was part of an inexorable process and for 6 partially so.

Care was generally judged good in 176 assessments rather than good and poor (n = 14) or poor (n = 7). The overall rating of care was good in the majority of cases at all timepoints: 67% before cardiac arrest, 91% during cardiac arrest, 91% after cardiac arrest and 80% overall. In five cases before cardiac arrest and in one during cardiac arrest, care was rated as poor. Fourteen (26%) patients were judged to have had poor care at some point and half of these patients died. In the five cases of poor care before cardiac arrest, there was no anaesthetist present at the time of the poor care. In two cases, the anaesthetist was called after a significant clinical deterioration; in two cases there were delays to treatment (one patient in ventricular tachycardia had waited several hours to come to the catheter laboratory because of capacity issues). In the one case of poor care during the cardiac arrest, a deterioration in the patient's condition was not communicated to the anaesthetic team leading to delays in appropriate treatment.

Panel review identified several common themes which included:

- cardiogenic shock
- late involvement of anaesthesia
- remote and/or unfamiliar locations leading to issues with access to drugs and equipment
- communication issues between specialties, especially when large numbers of staff were present, on occasion resulting in poor team working and lack of focus
- TAVI in five cases.

Reporters included an unwelcome number of comments about the lack of teamworking, poor task focus and logistical difficulties of the location.

Figure 37.2 The key causes contributing to cardiac arrest during cardiology procedures requiring anaesthesia

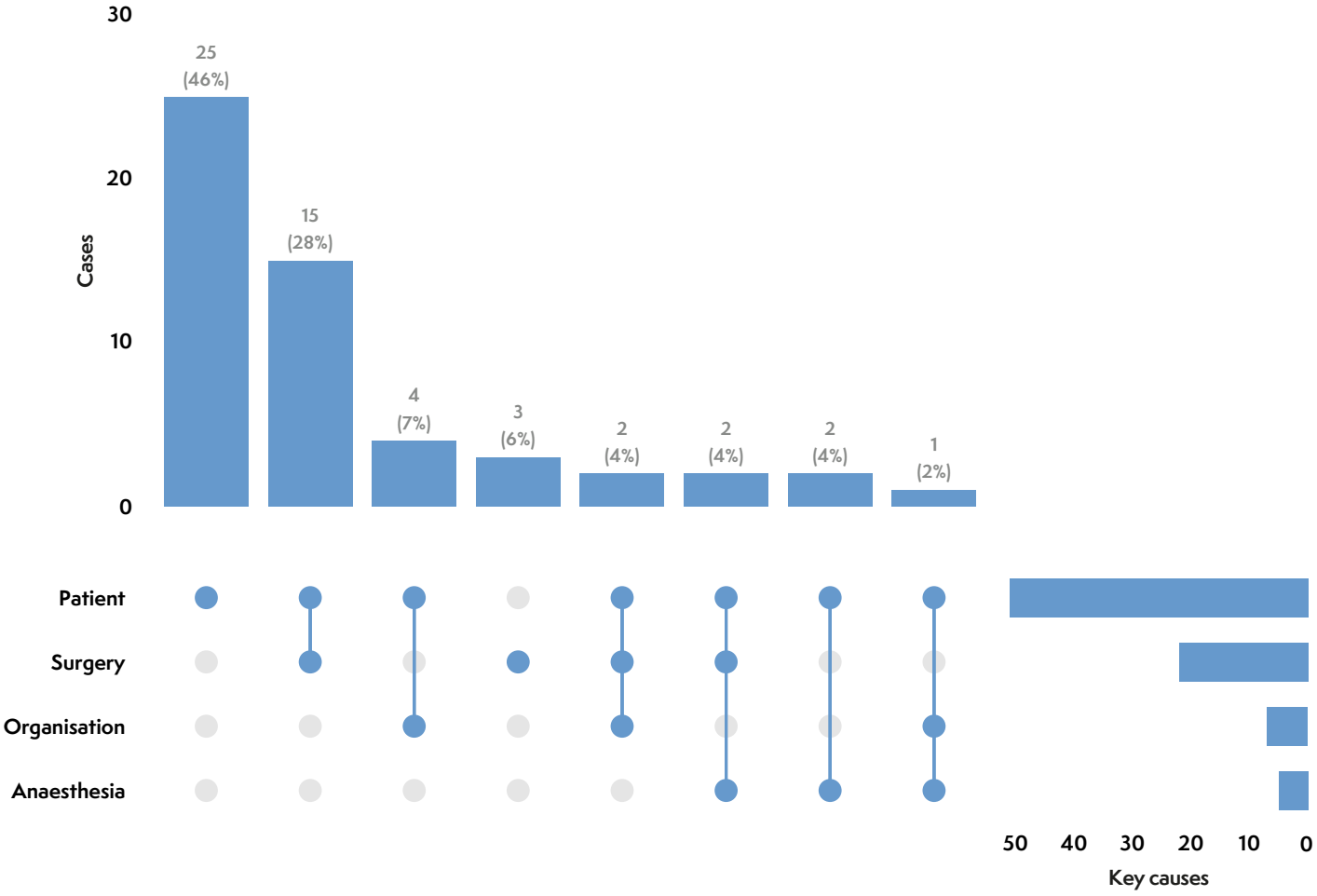
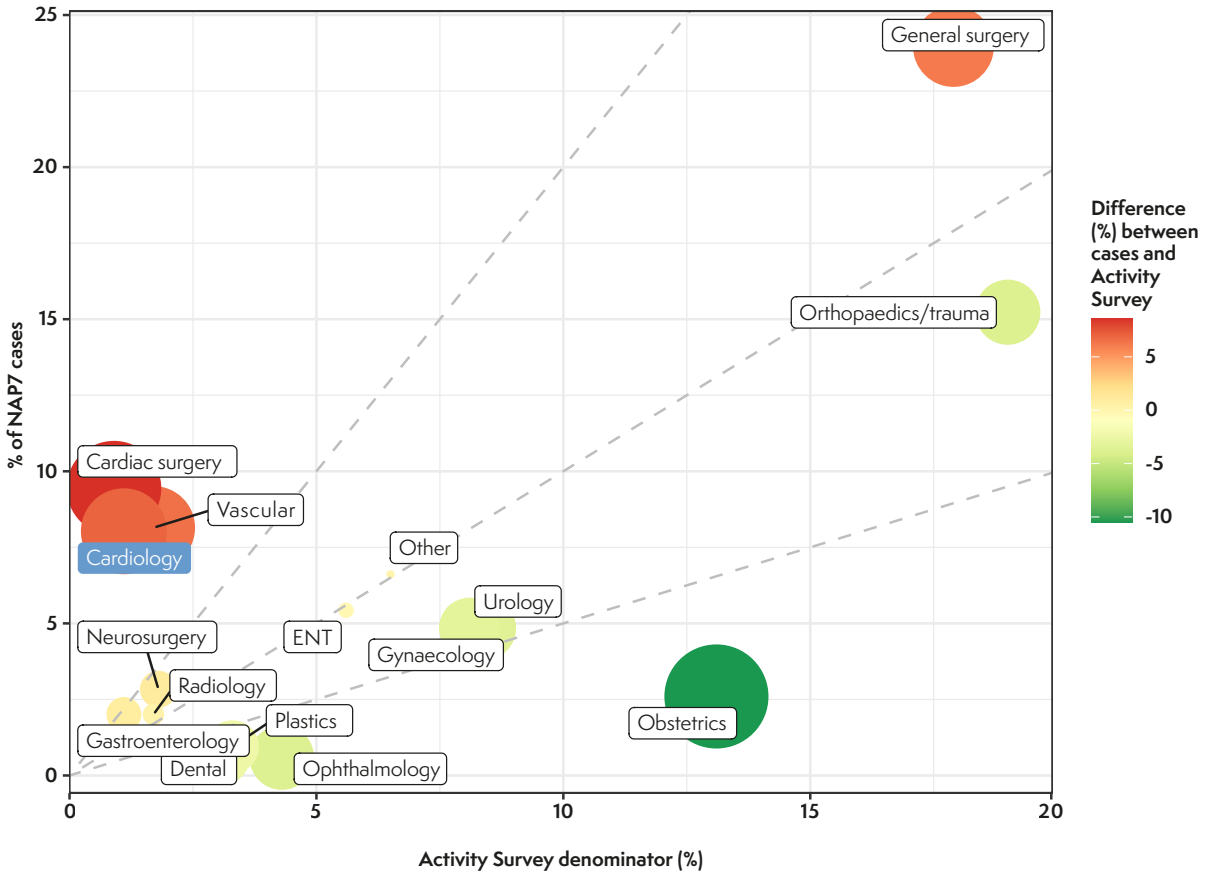


Figure 37.3 Proportion incidence of cardiac arrest in procedures requiring anaesthetic support. Size of coloured circle indicates magnitude of difference between proportion of cases in Activity Survey and case registry. Green circles are relatively underrepresented in the case registry and red circles relatively overrepresented. Dashed lines represent 2 : 1, 1 : 1 and 1 : 2 ratios. ENT, ear, nose and throat.



Discussion

The incidence of cardiac arrest was proportionately high in cardiological procedures requiring anaesthesia (Figure 37.3). Importantly, this chapter does not reflect all cases of cardiac arrest during cardiology procedures. NAP7 methodology did not include cases of cardiac arrest that occurred before an anaesthetist was called and only those involving anaesthesia care before cardiac arrest, including whether this was started before the procedure or as an emergency part-way through. The number of cardiac arrest cases reported are lower than was expected by the expert panel which may reflect under-reporting.

The patient demographics were consistent with the group of patients undergoing cardiological care but these patients are notably elderly, comorbid, inherently at risk of cardiac arrest and often undergoing an unplanned procedure in a remote location. As such, anaesthesia is particularly challenging, especially if called unexpectedly when planned care (without an anaesthetist) has become uncontrolled. This is compounded by the lower presence of consultants/post-CCT fellows at the start of anaesthesia care. Hospitals should ensure that calls for help are made in a timely fashion and that late calls for help when a situation has become irretrievable are avoided.

ST elevation myocardial infarction (STEMI) requires expedient management, akin to the category 1 caesarean section. The high mortality of cases that develop cardiogenic shock after STEMI means that expertise is needed to manage the circulation, and possibly the airway, while cardiologists are focused on revascularising the heart. It is notable that the few examples of poor care occurred before the arrival of the anaesthetic team. In acute ischaemic stroke thrombectomy services, an anaesthetist is an essential member of the procedural team, irrespective of the need for general anaesthesia (White 2017). Similarly, women in labour may never require anaesthetic assistance, but there are clear guidelines and plans in place regarding how it will be achieved reliably and expediently if the need arises. This is generally not the case in primary percutaneous coronary emergency intervention, which has a hospital mortality of around 50% in the context of cardiogenic shock. Almost half (48%) of patients reported to NAP7 who had undergone cardiological procedures could not be resuscitated acutely; more went on to die subsequently.

Cardiac arrests in this group occurred at all times of week and hours of the day. Whilst most common in hours (when activity was highest), they were more common than cardiac arrests out

of hours than in other specialities. This highlights the need for appropriately skilled anaesthetic support to be available at any time to assist colleagues in cardiology.

Cardiogenic shock is a complex condition to manage clinically with a high mortality following myocardial infarction. It is poorly identified and risk-stratified (Intensive Care Society 2022). Patients are often confused and have pulmonary oedema preventing them lying still for a procedure. However, induction of anaesthesia can often precipitate further cardiovascular decompensation. Specialised Shock teams are advocated in the care of cardiogenic shock. These teams generally comprise of a cardiologist, cardiac surgeon and cardiac intensivist. It is, however, worth noting that these teams are not usually resident, and they facilitate decision making rather than providing immediate care (Taleb 2019).

Cardiac arrests were mainly attributed to cardiac ischaemia and its effects. It is also worth noting that of the 23 patients who died, in 16 it was judged that this was at least in part due to an inexorable process. Given that death was not altogether surprising, it is relevant to examine consent and pre-interventional multidisciplinary decision making. There were only two instances of 'do-not-attempt cardiopulmonary resuscitation' (DNACPR) recommendations being in place in this group. Some of this is understandable because of the number of cardiac arrests that occurred in immediate (39%) or urgent (20%) cases, when there was presumably less time for meaningful discussion. Nevertheless, 41% of cardiac arrests occurred in non-urgent cases with at least five taking place during elective TAVI procedures. In particular, the review panel noted the case of a patient undergoing TAVI who had been deemed too frail for open surgery; when this patient subsequently arrested a decision was made to undertake emergency open surgery with a protracted period of intensive care (see also Chapter 20 Decisions about CPR).

The higher proportion of patients of Asian ethnicity is also notable making up 17% of those having a cardiac arrest, despite Asians being less than 4% of the overall patient population. It is well known that Asians from the Indian subcontinent (who form the majority of Asians in the UK) have higher rates of hypertension, diabetes mellitus and hypercholesterolaemia, all are risk factors for coronary artery disease and consequently cardiac arrest. However, there may also be social factors including access to health care contributing to a greater risk in this subgroup. This discrepancy should be the focus of future research aimed at elucidating causes and how this can be modified (see also Chapter 30 Ethnicity).

A frequent and disappointing theme appearing from cardiology reports to NAP7 related to difficulties in teamworking. Cardiac catheterisation laboratories are often remote locations for general anaesthesia, separate from the main surgical theatre setting. Patients outcomes must not be affected adversely by staff who are unfamiliar with one another, the setting and role allocations. Established tools such as multiprofessional simulation, team briefing and the National Safety Standards for Invasive Procedures can enable team working and thus improved patient safety. Late involvement of anaesthesia exacerbates the problem as many of these current interventions to improve team working occur at the start of a case. An example course is the Cath-Lab Emergency Medical Simulation, which was designed specifically to develop the knowledge and skills needed to work effectively as a team in catheter laboratory emergencies (Cardiac Diagnostics Education Centre 2023).

There were a few cases of eCPR reported in the NAP7 cohort, occurring in only three (5.5%) cases in those who were undergoing cardiological procedures. In the whole NAP7 cohort, eCPR was also uncommon, access was by emergency re-sternotomy and cardiopulmonary bypass, the majority of which were in cardiac surgery rather than cardiology cases. This reflects the lack of availability of eCPR in UK hospitals, particularly out of hours, as well as the stringent criteria which must be fulfilled for eCPR to be offered. The evidence for eCPR is changing, and it was recently demonstrated in a meta-analysis and trial sequential analysis that the use of eCPR in eligible patients with in-hospital cardiac arrests reduced not only in-hospital mortality significantly but also post-arrest survival and long-term neurological outcomes (Low 2023). The use of eCPR has been growing in Europe and in North America. Joint British societies guidelines recommended that units investigate the use of ECMO as a further means of supporting patients who do not recover after cardiac arrest in the catheter laboratory (Dunning 2022).

A patient was admitted with chest pain and an elevated plasma troponin level. They were taken for PCI without involvement of an anaesthetist. The patient was administered benzodiazepines for increasing agitation which was ineffective. Support from an anaesthetist was requested to facilitate the procedure. The patient had a cardiac arrest following induction of general anaesthesia and the PCI was not completed. The patient was transferred to the ICU on inotropes and transvenous pacing, but died soon afterwards when the situation was judged irrevocable. Difficulties in teamworking and poor communication were commented on by the reporter. The review panel felt that the agitation was a manifestation of cardiogenic shock and induction of anaesthesia was always going to be challenging.

A patient was admitted following primary percutaneous intervention for an acute coronary syndrome. They subsequently developed cardiogenic shock so a plan was made to repeat coronary angiography and insert an intra-aortic balloon pump. No anaesthetic support was arranged. During the procedure the patient became agitated and hypotensive. When the patient's level of consciousness fell, an anaesthetist was called urgently. On arrival, the patient was in extremis. Soon after tracheal intubation the patient had a PEA cardiac arrest. Resuscitation attempts were unsuccessful and the patient died. The reporter felt that the anaesthetist had been called late when the patient was difficult to manage. The NAP7 panel judged that that the cardiac arrest may have been avoidable.

Recommendations

National

- Stakeholder organisations should develop guidelines for patients requiring anaesthetic support when undergoing urgent and emergency cardiological procedures.

Institutional

- Departments should develop robust guidelines for which patients require anaesthetic support for cardiological procedures and how this will be delivered acutely. Late calls for support should be avoided, monitored and reviewed.
- Support for cardiological procedures should have the experience and skills to care for patients with cardiogenic shock. This may need to be consultant delivered in and out of hours from anaesthesia and/or ICU. These services may require additional funding to staff appropriately in the required timescales.
- Hospitals that provide interventional cardiology services should ensure that all members who may be called to provide anaesthetic assistance are familiar with the catheter laboratory environment. Guidelines and training should be in place to ensure efficient focused team working in the event of a cardiac arrest. This may include the use of a specialist shock team. This must include nurses and doctors in training as many arrests occur out of hours.
- Extracorporeal cardiopulmonary resuscitation and mechanical circulatory support may rescue some patients. Departments should establish links with providers of mechanical support so that all patients will have the opportunity to benefit from this care.

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