Catheter Laboratory Design, Staffing and Training

6

Cara Hendry and Rizwan Rashid

6.1 Introduction

Treatment of acute myocardial infarction has improved dramatically in recent years. Primary percutaneous coronary intervention (PPCI) has now become the mainstay of treatment and is available to all but a few geographical catchment areas in the UK. Annually over 24,000 primary PCIs are performed in the UK representing approximately a quarter of the total coronary intervention cases each year [1].

From national registry data in the UK, the reported mortality risk of patients with acute myocardial infarction receiving PPCI is of the order of 6%. Published literature demonstrates that this mortality risk may rise to 40–50% in patients who develop cardiogenic shock.

Patients undergoing primary angioplasty are therefore amongst the highest risk group of patients receiving coronary intervention. It is vital that we should seek to reduce that risk as much as possible by having well-trained teams who work in an optimum environment.

6.2 Personnel: The "Cath Laboratory Team"

The most valuable asset of any catheter laboratory is without doubt the catheter laboratory team. Without a good team, even a catheter laboratory in possession of the most abundant resources will not function as a safe and efficient clinical environment.

C. Hendry (✉) · R. Rashid
Manchester University NHS Foundation Trust, Manchester, UK
e-mail: cara.hendry@cmft.nhs.uk

T. J. Watson et al. (eds.), *Primary Angioplasty*,
https://doi.org/10.1007/978-981-13-1114-7_6

The composition of the catheter laboratory team will vary between centres but, broadly speaking, will consist of the following team members:

- Consultant interventionist
- Interventional trainee (registrar or fellow)
- Nurses (ideally at least two per laboratory)
- Radiographer
- Cardiac physiologist
- Ancillary/domestic staff
- Management/catheter laboratory director

This list is by no means exhaustive. Additional teams may attend the catheter laboratory on a regular basis, for example, the anaesthetic team including anaesthetist and emergency airway practitioner (EAP), who may be required to attend when patients have compromise of their conscious level and/or airway problems or are requiring critical care support. This is a common scenario in most centres, especially when treating patients who have return of spontaneous circulation (ROSC) after suffering an out-of-hospital cardiac arrest. This particular group of patients may deteriorate rapidly and thus require a very high level of clinical suspicion and hence very close supervision.

For procedures requiring conscious sedation (in the UK), the Association of Anaesthetists of Great Britain and Ireland (AAGBI) has issued specific guidance for how these patients should be monitored and managed in the peri-procedural environment, including the need for capnography [2]. The catheter laboratory and recovery area must therefore possess the ability to monitor end-tidal CO_2 to ensure these patients are appropriately monitored and managed.

The time-dependent nature of managing patients with acute STEMI means that catheter laboratory lists must have capacity to be flexible and allow for patients requiring emergency procedures, sometimes with only a few minutes notice. Local arrangements with ambulance services are key aspects in ensuring this is implemented in an efficacious manner. Good working relationships, regular interaction and feedback to and from the ambulance teams are essential to improve and streamline processes. It is useful to have a member of staff allocated on a daily basis to co-ordination of catheter laboratory activity who can act as a contact point for ambulance activation and alter schedules to accommodate emergencies. This can be a complex and stressful role, so ideally this role should be rotated amongst experienced staff to lessen the burden.

The catheter laboratory is an environment where team members may be exposed to situations which are potentially extremely stressful, and it is essential that they are provided with the appropriate training and skills to enable them to deal with this in a way that will protect them from burnout and post-traumatic stress, which are increasingly being recognised as occupational hazards amongst emergency medical teams.

It is important to ensure that the workforce is well supported in terms of education and physical resources (equipment). Of at least equivalent importance is to

ensure that emotional support is available. These measures, in turn, will reap rewards in terms of the well-being and retention of staff.

6.2.1 Education

The role of ongoing education in maintaining the highest standards of care in the catheter laboratory cannot be underestimated. In an environment where standards are often updated and evidence rapidly developing, keeping staff up to date must be part of the ongoing catheter laboratory activity.

There are a variety of methods which may be employed in doing so—from teaching during cases (including debrief) to separate educational sessions (which should be considered to be mandatory in maintaining skills and knowledge) with traditional classroom-style teaching and training in practical skills with manikins. Simulation is an extremely useful method of teaching and has obvious advantages in training staff to be familiar with a variety of both routine and emergency scenarios. If using simulation, it is useful to poll the team beforehand to identify any obvious knowledge gaps in order to plan sessions in order of importance. The obvious disadvantage of simulation is that it is resource and personnel-heavy, and therefore it must be planned very carefully. Overall, simulation is felt to be one of the most valuable methods of training and education for the team, and it has the obvious advantage of enhancing communication and relationships between the team members.

There are a variety of simulation courses available for all team members, but there is no substitute for teams being familiar with one another's skills, environment, local arrangements, policies and equipment. The workplace is therefore the ideal environment for simulation.

In addition to the above methods of learning, the role of debrief deserves to be considered separately as it is an important method for team members to discuss their performance (as part of routine clinical practice and after emergencies or simulation) in a safe, noncritical environment. It is important that this is delivered in a supportive environment as participants may feel particularly vulnerable after an event, and early debrief can reduce stress levels and identify individuals requiring extra support early on.

6.2.2 The Workforce

Let us now consider the core (non-medical) members of the team in more detail.

6.2.2.1 Nursing Staff

Nursing staff will be registered with the Nursing and Midwifery Council (in the UK) or equivalent registration body in other countries. They will usually have to work for a minimum of 2 years post-qualification prior to working in the catheter laboratory environment, but this varies widely from centre to centre. Ideally two

nurses should be present during primary PCI—one scrubbed or administering drugs and one circulating nurse or "runner" to retrieve necessary drugs and/or equipment. They should be familiar with the administration of drugs required during primary PCI as well as pressors and those required during emergency intubation and resuscitation.

6.2.2.2 Allied Healthcare Professionals

The group of allied health professionals (AHPs) includes radiographers and physiologists and may include operating department practitioners/physician associates. The roles of many of the AHPs and of the nursing team may overlap significantly, and it is very useful for each member of the team to be familiar with the processes which their colleagues must carry out during the procedure to facilitate efficient working. Some centres have also adopted a policy of training AHPs to be proficient in performing the skills of multiple AHP groups in order to improve flexibility and improve patient care. These roles may be named as catheter laboratory practitioners, and training may be nationally by a postgraduate certificate or by local processes.

6.2.2.3 Radiographer

Radiographers in the catheter laboratory will be in possession of a degree in diagnostic radiography which (in the UK) has been approved by HCPC (Health and Care Professions Council) and will have to work post-qualification in imaging radiology for a period of 1–2 years before working in the catheter laboratory environment. After this period, they will usually work in the catheter labs for 3–6 months in order to achieve competency in primary PCI procedures. In the UK, there is usually one radiographer for each catheter laboratory who operates the C-arm and moves the table, but this practice varies in other countries such as North America, where typically the interventionist will operate the C-arm and one radiographer may then be used to cover two labs (where there is a shared control room for two labs).

6.2.2.4 Physiologist

Specialised cardiac physiologists working in the catheter laboratory will possess a degree in physiology (or will have achieved satisfactory competence by local training) or healthcare sciences and will specialise in cardiology. They will be registered with HCPC (UK) and the equivalent body in Europe and beyond. They will usually work under supervision for a period in the catheter laboratory (varies from centre to centre) before being considered sufficiently experienced to participate in catheter laboratory on-call rotas. The role includes monitoring and identifying cardiac rhythm and pressures and in many labs extends to preparing and monitoring adjunctive therapy with devices such as intra-aortic balloon pump or Impella. It is recognised that in some surgical centres, insertion of these devices is supported by the perfusion team.

It is important for the team to work in a cohesive manner and identify as part of a team providing excellent care to patients. All members should remember that although they have been involved in many procedures, for the patient it may be their

first and perhaps only one. The impact of this on patients is not to be underestimated, and all should invest their time to ensure patients are dealt with in a sensitive and dignified manner.

6.2.3 Structure and Location of the Catheter Laboratory

The environment of the catheter laboratory and its surroundings should enhance patient care and protect patient and staff from physical harm.

6.2.3.1 Location

Before stepping into the catheter laboratory, it is worth taking into consideration where the catheter laboratory would ideally be housed within a hospital. Ideally, this would be within a short distance from an ambulance entrance which does not require use of an elevator to provide access to the catheter laboratory in order to reduce the transit time for critically unwell patients and minimise delay to reperfusion in ST segment elevation myocardial infarction. For centres receiving patients from helicopter transfers, proximity to the helipad should likewise be given consideration.

For those environments where there is direct access from the community medical services, the ambulance entrance to the cardiac catheter laboratory should be very clearly signposted to enable paramedics unfamiliar with the hospital to easily identify the access route, and additional signposting should make the remainder of the route equally visible. Patients will also frequently be admitted to the catheter laboratory from the emergency department (ED); therefore co-location to the ED would be desirable, as would proximity to the cardiology wards (for inpatient transfers) and the cardiac operating theatres (in tertiary centres) for the rare occasion in which patients are required to be directly transferred from the catheter laboratory for emergency surgery.

As many patients coming to the catheter laboratory are of an acute nature, a waiting area for relatives should be provided. This should be shielded from the public eye and be comfortable with adequate seating provision for larger families. It should be easy for relatives to contact staff if they have any queries. It is advisable that the relatives' room should be close to, but not directly connected to, the catheter laboratory and the catheter laboratory recovery area should not be directly visible to relatives. This will potentially reduce unnecessary anxiety from watching members of staff conducting their duties and relatives overhearing conversations which may or may not apply to their family member.

6.2.3.2 Staff Facilities

Adjacent to the catheter laboratory, there should be adequate facilities for staff to change and securely store personal belongings as well as washing and showering facilities for decontamination purposes. Rest/break facilities should also be provided; again, this would be ideally located in close proximity to the catheter laboratory to avoid time lost by employees in transit and to facilitate contact with teams

should there be an emergency requiring support of additional colleagues. Rest facilities should be clean and comfortable and have facilities for preparing and cooking meals.

6.2.4 The Catheter Laboratory

The catheter laboratory area will generally comprise of an access corridor and entrance to the laboratory with a separate entrance to a control room.

6.2.4.1 Entrance

As the catheter laboratory is a designated area where ionising radiation is used, it is mandatory for "X-ray on" illuminated safety warning sign to be placed in a prominent position at each entrance and also at the entrance to the laboratory from the control room. These must be clearly visible and illuminate in red when they are energised. They must state "No Entry" clearly, visible only when illuminated. The lamps are automatically switched on when the X-rays are being utilised and as such are wired into the X-ray activation system. These signs should have power provided in the essential and emergency backup electricity supply.

6.2.4.2 Control Room

In most catheter laboratories, the physiologist will be located along with monitoring equipment and IT equipment. They are separated from the procedure room by lead glass to enable direct visualisation of the patient and equipment while being protected from unnecessary radiation exposure. There should be good vocal contact between the control room and the laboratory—for this reason, it is usual to have a microphone system installed to amplify both operator and physiologist. It is essential that the physiologist has a clear view of the patient table to detect a change in the patient's condition. In some centres, a single control room will be shared between two laboratories. If a shared control room is used, then access to either laboratory should be unobstructed.

6.2.5 The Procedure Room

The recommended minimum dimension for a procedure room is stated to be 50 m^2. This is noted to be sufficient to accommodate the necessary equipment and up to eight members of staff [3]. Sufficient dimensions are required to permit safe passage of staff into and out of the room and for a patient to be transferred in on a trolley or bed with safe access to equipment as necessary.

Basic requirements include piped medicinal gases via adaptors—including pressurised air and oxygen. Traditional wall sources have the potential to get caught in the C-arm operation and must be placed in position to minimise both this and trip hazards. Options exist to pipe these via floor or ceiling. For rooms where implantable devices will be placed (e.g. pacing procedures, trans-catheter valve

replacements), air flow and ventilation systems must comply with the standards expected in operating theatres.

6.2.5.1 Safe Practice

An abbreviated form of the World Health Organization safe surgical checklist should be displayed in a prominent position on the wall, and this should be completed as a "team brief" before the patient enters the catheter laboratory. This facilitates safe handover when members of staff may enter or leave the room during a procedure.

Upon the patient entering the laboratory, a safe surgical checklist should be completed to minimise unnecessary risk to the patient and ensure the team are aware of any significant clinical issues which may affect the procedure. In PPCI the paramedics should form part of the check-in as they may have administered drugs or may possess additional information.

6.2.5.2 Clinical Preparation Areas

A scrub trough and gloving-up area, which may be within the procedure room or in an adjacent room, will be required. Ideally this should be placed in a position to minimise the number of staff walking past to avoid de-sterilisation.

6.2.5.3 Radiation

At the time of writing, the legislation regulating the use of ionising radiation (UK) is the Ionising Radiation Regulations, commonly referred to as IRR 99, and these are enforced by the Health and Safety Executive. It is expected that these will be replaced by IRR 17 at the beginning of 2018, subject to parliamentary approval.

The guiding principle of radiation protection remains that of "as low as reasonably practicable" or ALARP as it is commonly described.

The catheter laboratory is defined as a designated area from a radiation protection viewpoint. Its boundaries must be clearly identified. There is a legal obligation to describe the nature of the radiation and the potential risks of exposure. All members of staff working within the designated area must be issued with appropriate training, and this information must be recorded and retained.

Personal protective equipment is also mandatory in this environment to avoid unnecessary radiation exposure to personnel. This may involve traditional lead aprons, which can be issued in a variety of forms, i.e. one or two piece. Additionally, areas particularly sensitive to radiation exposure must be protected by means of lead thyroid collar, lead glasses and leg shields.

In addition to protective clothing, further radiation protection should be available in the form of ceiling-mounted eye shield and a hanging "skirt" which is suspended from the procedural table, and these should be positioned in each case to minimise exposure to operator and assistant.

Should anaesthetic or airway support be required, it is useful to have a mobile screen which can be wheeled into position between the radiation source and assisting team members.

6.3 Protective Equipment

6.3.1 Lead Gowns

Leaded aprons/thyroid/leg shields/leaded glasses should be provided and stored outside of the entrance to the catheter laboratory area. These should be hung on reinforced racks due to their weight. These should be carefully labelled, identifying the level of protection afforded by each.

6.4 Equipment

Each catheter laboratory should contain the necessary equipment in order to safely perform the angioplasty procedure while minimising hazards to staff.

6.4.1 X-Ray Equipment

6.4.1.1 Image Intensifier

The digital angiographic X-ray system may be single or biplane and is usually floor mounted although ceiling-mounted systems are available.

6.4.1.2 Examination Table

This should be fully adjustable capable of multidirectional movement and be placed in a position which allows access to the patient from both sides. When selecting a table, consideration should be given to the treatment of bariatric patients. The C-arm should be able to be moved without restriction. If biplane equipment is installed, the room should be longer along the axis of the table to allow space for movement of the second C-arm. The procedural table should be placed in an area where there is adequate space at the cranial end to allow an area for attending anaesthetist/airway practitioners to perform their duties safely should they be required. At the head end, an anaesthetic machine would be desirable in each catheter laboratory where use of sedation may be required—this allows for additional monitoring, in particular capnography, and the facility to administer anaesthetic gases should they be required (see Fig. 6.1). A power injector system for contrast injections (usually ceiling or table mounted) should also available for use.

6.4.1.3 Monitors

Display equipment for angiographic, ECG and pressure data is commonly ceiling mounted and mobile via an overhead gantry to accommodate for positioning of the C-arm. The number of monitors required will vary from centre to centre—with a minimum of three (pressure and ECG data, current image and stored reference image). Additional screens may be installed for display of intravascular imaging (such as integrated intravascular ultrasound or optical coherence tomography) or pressure wire data. The monitor position should be adjustable to permit the operator to view images comfortably.

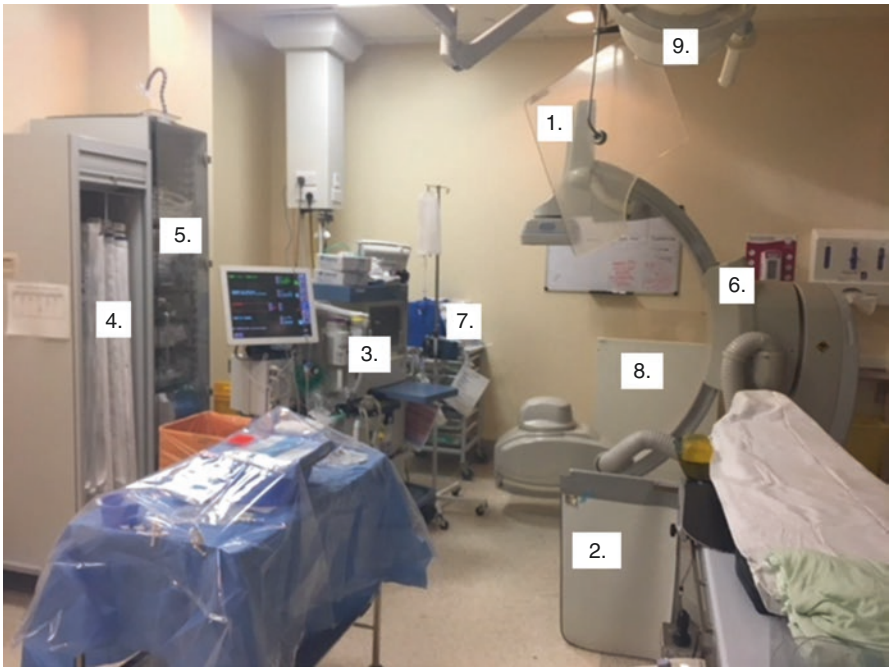

Fig. 6.1 Potential arrangement of catheter laboratory equipment. ***1***. Transparent ceiling-mounted protective eye shield. ***2***. Leaded radiation—protective skirt mounted on catheter laboratory table. ***3***. Anaesthetic machine. ***4***. Mobile cabinet containing cardiac catheters. ***5***. Mobile cabinet containing stents and balloons. ***6***. C-arm in stowed position. ***7.*** Emergency equipment trolley-containing airway kit, pericardiocentesis set, etc. ***8***. Portable adjustable radiation protection screen with leaded glass upper section. ***9***. Ceiling-mounted operating light

6.4.1.4 Work Surfaces

A work surface is required for drug preparation and completion of paper documentation.

6.4.2 Storage

6.4.2.1 Drugs

In acute myocardial infarction, opiate analgesia is commonly required; thus the presence of a wall-mounted controlled drug cupboard within the procedure room is desirable to avoid the need for members of nursing staff to leave the operating environment during a procedure to retrieve medications. Similarly, there should be a locked cupboard to store other intravenous fluids and drugs, both injectable and oral, which may be required during the procedure. A heated lotion cabinet should also be available in the procedure room for storage of contrast media.

6.4.2.2 Consumables

Catheters are best stored in hanging racks to enable ease of identification and rapid retrieval for use. These may be housed in mobile units which may be moved to a variety of positions or between labs should this be required. Likewise, miscellaneous equipment, such as for cannulation, vascular access sheaths, balloons and stents, etc. should be available in the procedure room—these may be stored in mobile cabinets or wall-mounted cupboards. Extra storage for additional stock will be required in a separate area (located nearby) to avoid cluttering the procedural room unnecessarily. Items used less frequently may be located in an adjacent storage area.

6.4.2.3 IT Equipment

Computer workstations are required—the number of these will vary—but generally at least two of these will be required. The physiologist will be required to enter contemporaneous data and thus will require a workstation (usually located in the viewing "control" room)—ideally with three screens (one for inputting data, the other for viewing an uninterrupted rhythm and pressure strip and finally a screen for viewing the current fluoroscopic image). The nursing team will also require a computer (ideally a portable workstation on wheels within the procedure room) to enter data and record drug administration, etc. The anaesthetic team may also require a workstation on wheels (ideally this will be incorporated into the anaesthetic machine) to enable data entry and recording of haemodynamic pressures/anaesthetic drug administration, etc. The majority of cables should either run underfloor or overhead to avoid trip hazards.

6.4.2.4 Emergency Equipment

Every laboratory should have an emergency trolley which houses the necessary equipment should there be a life-threatening emergency. This will include (but is not limited to) emergency airway equipment, emergency drug box and pericardiocentesis set. This trolley should be clearly marked and visible. Access should be unimpeded by equipment or personnel. All staff should be familiar with its location and contents. A small stock of covered stents should also be readily available for rapid access in the event of a coronary perforation.

6.4.2.5 Defibrillator

Patients with acute myocardial infarction have a very high risk of arrhythmia, and a defibrillator should be positioned close to the patient to enable rapid defibrillation in the event of a compromising heart rhythm disturbance. All catheter laboratory staff should be familiar with the operation and functionality of the defibrillator. Centres may elect to attach the patient to the defibrillator to prevent delay in defibrillation due to time taken to attach pads to the chest. The capability of the defibrillator should include the ability to externally pace the myocardium should this be required, while more definitive management of bradycardia is arranged (i.e. temporary

pacing). Those defibrillators with adhesive pads may be preferable to use of paddles as this facilitates rapid and safe shock delivery while permitting continuation of the PCI procedure. This is particularly relevant for those cases where there are recurrent/frequent bouts of VF/VT.

6.4.2.6 Pacing Equipment

In acute myocardial infarction, particularly those affecting the inferior territory, patients are at high risk of bradycardia and complete heart block. Each laboratory should therefore possess the facility to perform temporary pacing—necessitating pacing box, a stock of temporary wires and batteries for the pacing boxes.

6.4.2.7 Mechanical Chest Compression Device

Provision of effective CPR during a PCI is extremely challenging due to physical factors such as the C-arm placement, table height and the risk of radiation exposure to the person performing CPR. The use of a mechanical device such as LUCAS® or AutoPulse® will enable good-quality CPR to be delivered, while the PCI procedure is continued. This has obvious advantages in any cath laboratory performing PCI. It is suggested that the device would be stored in the catheter laboratory—or if more than one laboratory performing PPCI, in a place which is easily accessible and unobstructed. All staff should be familiar with the device, and it should be checked regularly to ensure all components are present and in good working order.

6.4.2.8 Intra-aortic Balloon Pump (IABP)

Although the IABP is much less commonly used as a result of the SHOCK II trial data, there is still a place for its use in patients with refractory ischaemia/those with post-MI mechanical complications. The pump should be stored near the PPCI catheter laboratory, and its location should be familiar to the catheter laboratory staff. The operator and physiologist (perfusionist in some tertiary centres) ± other team members should be trained in its indications and use and be familiar with the model available.

6.4.2.9 Ventricular Support Devices

The use of ventricular support devices in treatment of patients with cardiogenic shock is increasing worldwide. At the time of writing, there is only one device (Impella®) available for clinical use in the UK, although other devices are in development, both nationally and worldwide. The Impella® device consists of a mobile unit (controller) which is easily transportable via a stand on wheels and the implantable device which is attached by a series of cables. If available, the device and the corresponding consumables should be stored at a location close to the catheter laboratory. This is not considered to be a mandatory device in management of cardiogenic shock; nonetheless in selected cases, it may be extremely valuable and merits consideration.

6.4.3 Adjunctive Devices

6.4.3.1 Rotational Atherectomy

This is less commonly required during primary PCI but is occasionally useful in this setting. Most tertiary centres perform rotational atherectomy, but there are some lower-volume interventional labs where rotablation is not available, and these patients would commonly be referred to the tertiary centre for the procedure. The consumable components to the equipment are usually stored in a shared store room for the catheter labs as they are large, and the console should be housed in a dry storage space which is known to all laboratory staff. If using portable cylinders of pressurised air, they should be housed in a safe location and should be checked regularly to ensure there is an adequate air supply.

6.4.3.2 Intravascular Imaging: Optical Coherence Tomography (OCT) and Intravascular Ultrasound (IVUS)

These widely used systems are both available as mobile console units, and with both technologies, it is possible now to purchase integrated units where the operational equipment is integrated into the catheter laboratory table and monitoring display equipment. There are obvious advantages and disadvantages of integrating the equipment—these being that it limits use of the device to a single procedure room and there is additional cost involved in installation. The advantage is that in doing so, it permits use of co-registration (which although not essential is clearly a desirable property in assessing the nature and extent of complex disease). Additionally, integration allows for more free space in the laboratory, and fewer trip hazards created by free cables, which may be accidentally disconnected. If using mobile consoles, a dedicated storage space in close proximity to the coronary labs which is known to all labs is most useful. If only one of these pieces of equipment is to be purchased, then arguably the most useful device would be intravascular ultrasound, as there are no specific cases in which it cannot be used. OCT and IVUS are extremely useful in detection of malapposition, which is particularly useful as it is one of the main risk factors for stent thrombosis after PPCI. Notably though, neither modality has been definitively proven to alter acute outcomes following primary PCI.

References

1. BCIS database 2013 data
2. Checketts MR, Alladi R, Ferguson K, Gemmell L, Handy JM, Klein AA, Love NJ, Misra U, Morris C, Nathanson MH, Rodney GE, Verma R, Pandit JJ. Recommendations for standards of monitoring during anaesthesia and recovery 2015: Association of Anaesthetists of Great Britain and Ireland. Anaesthesia. 2016;71(1):85–93.
3. Department of Health Publications. Health Building Note 01-01: Cardiac Facilities.