Joint British Societies' guideline on management of cardiac arrest in the cardiac catheter laboratory

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ABSTRACT

atories in the UK each year. The variety and complexity of percutaneous cardiovascular procedures

of invasive cardiology, when it was largely focused on elective coronary angiography and single chamber (right ventricular) permanent pacemaker implantation.

primary percutaneous coronary intervention, cardiac resynchronisation therapy, complex arrhythmia ablation and structural heart interventions. These procedures all

We have developed evidence-

atory. The guidelines

collaboration between nine professional and patient

ascular conditions. We

whole catheter laboratory team and which are aimed

who suffer a cardiac arrest in this setting. We identified

laboratory. We recommend that all catheter laboratory staff undergo regular training for these emergency situations which they will inevitably face.

catheter laboratories in the UK each year. The variety and complexity of procedures undertaken in the cardiac catheter laboratory have

sive cardiology has grown from a largely diagnostic specialty focused on elective coronary angiography to one that treats a wide spectrum of cardiovascular

sation procedures, for example, are now performed by percutaneous coronary intervention (PCI), and

of acute ST elevation myocardial infarction. Pacemaker implantations have evolved from mostly right ventricular procedures to treat bradycardias resynchronisation therapy for patients with left ventricular dysfunction and/or implantable cardioverter defibrillators (ICDs) for patients at risk of ventricular arrhythmia. Complex arrhythmia ablation procedures have become more common as

Recent years have seen a large increase in structural heart interventions driven by transcatheter aortic valve implantation (TAVI) to treat aortic stenosis, adding a further level of complexity to procedures undertaken in the catheter laboratory. Percutaneous interventions on the mitral valve are increasing in number while the tricuspid valve and heart failure syndromes are targets for interventional technology

patients who are elderly and comorbid, with limited

eter laboratory all carry the risk of complications which lead directly or indirectly to cardiac arrest. Careful assessment of the risks and benefits of the procedure is required for each patient. In many cases, the risk of cardiac arrest is low. In others, such as primary PCI, the risk is appreciable. The incidence of cardiac arrest during PCI is approxi
The chance of successful resuscita
ital cardiac arrest

expert team which is present at the time of cardiac arrest, the reason for the cardiac arrest may be known, and it may be reversible through an intervention in the catheter laboratory. Other specialists are usually readily available to assist, if required.

laboratories, for example, whether they are based in a cardiac surgical centre or in a district general

roles which they undertake in the catheter laboratory. Furthermore, the intervention to achieve restoration of spontaneous circulation (ROSC), such as PCI, may take some time to perform. Rescuers who are used to 10–15 arrest scenarios may need to become familiar with prolonged cardiac arrest scenarios which involve mechanical cardiopulmonary resuscitation (CPR), the administration

of the patient's physiology, and treatment akin to

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that of a critically ill patient on an intensive care unit (ICU). In undertaking invasive procedures in the catheter laboratory, our

is needed. For this reason, we have developed evidence-

for the management of cardiac arrest in the catheter laboratory.

SCOPE AND METHODS

This guideline covers adult patients undergoing any invasive procedure in the catheter laboratory, including coronary angi ography, PCI, structural heart interventions including TAVI and mitral valve procedures, pacemaker and ICD implantation, arrhythmia ablation, atrial appendage occlusion, and pacing system extraction. We did not consider patients who suffer a cardiac arrest and are then brought to the catheter laboratory as these patients have recently been considered in a position paper

(BCS), the British Cardiovascular Intervention Society (BCIS), the British Heart Rhythm Society (BHRS), the British Associa tion for Nursing in Cardiovascular Care, the British Society of Echocardiography, the Association for Cardiothoracic Anaes thesia and Critical Care, the Cardiovascular Care Partnership UK, the Society for Cardiothoracic Surgery in Great Britain and Ireland, and the Resuscitation Council UK.

Resuscitation Council UK 2021 guidelines development process. We used the ESC 2018 practice guidelines recommendations for

levels of evidence in support of them. It should be acknowl edged that the literature surrounding cardiac arrest comprises mostly of papers which reported the findings of studies after

ital cardiac arrest rather than

We undertook a comprehensive review of the literature and a Delphi expert consensus process in order to identify all of the situations in the catheter laboratory that potentially lead to cardiac arrest and to provide team-

e propose these guidelines as the standard of

According to international guidelines, resuscitation is governed by The International Liaison Committee on Resuscitation (ILCOR) which is a collaborative of seven world resuscitation councils which was founded in 1992. The full range of all recom mendations in the area of resuscitation is reviewed and updated

The seven resuscitation councils then take this evidence and

The American Heart Association guidelines

The 2015 American Heart Association (AHA) guidelines contain a two- section entitled 'Cardiac Arrest During Percutaneous Coronary Intervention', although this was omitted from its 2020

sion on the use of automated CPR devices over manual compres sions and the use of extracorporeal CPR (ECPR) devices. It did not come to any firm conclusion but stated that mechanical CPR

interventions such as coronary artery bypass surgery, cardiac transplantation or longer- mechanical devices. In the text of the guideline it is also noted by the authors that early defibril lation within a minute of cardiac arrest is associated with excel lent outcomes. No other special considerations were discussed with regard to the management of cardiac arrest in the catheter laboratory.

The European Resuscitation Council guidelines

The European Resuscitation Council (ERC) published guidance regarding resuscitation in the catheter laboratory in 2021 in its document entitled 'cardiac arrest in special circumstances'. It included a protocol diagram, and there was a strong emphasis on ensuring that catheter laboratory staff are adequately trained in resuscitation technical skills including team training, and specific protocols for the initiation of mechanical CPR, temporary pacing and pericardiocentesis, with the use of on-

The ERC also recommended the availability of resuscita tion equipment and the use of checklists. Mechanical CPR was recommended due to the risk to staff from manual CPR during fluoroscopy, and the requirement to continue CPR during PCI.

The Australian and New Zealand guidelines

These guidelines discussed the use of mechanical CPR in cardiac

found case reports regarding its use during electrophysiology (EP) procedures. They discussed treatment of cardiac tamponade during cardiac arrest by thoracotomy and pericardiotomy if peri cardiocentesis fails with a class B recommendation. They noted that the interventionalist is heavily task burdened and, as such, is seldom in a good position to lead the resuscitation and that there may be tension between the requirement to perform CPR and the ability of the interventionalist to continue with the proce dure, thus acknowledging two of the particular challenges faced

A NOVEL PROTOCOL FOR THE MANAGEMENT OF PATIENTS WHO SUFFER A CARDIAC ARREST IN THE CATHETER LABORATORY

We have developed a modified resuscitation protocol which is specifically designed for the specialist area of the catheter labo ratory. Of note this does not apply to recovery areas but does apply to hybrid laboratories where TAVI or Mitraclip proce dures are being undertaken. This protocol could also be used

aortic repair (TEVAR). The full protocol is shown in

How should cardiac arrest be identified, defined and

In a catheter laboratory a cardiac arrest is identified much more quickly than other in- -

lation (VF), pulseless ventricular tachycardia (VT) and asystole

constitutes a cardiac arrest in a catheter lab. In contrast to the two pathways in the standard

ways: VF or pulseless VT, asystole or extreme bradycardia, and

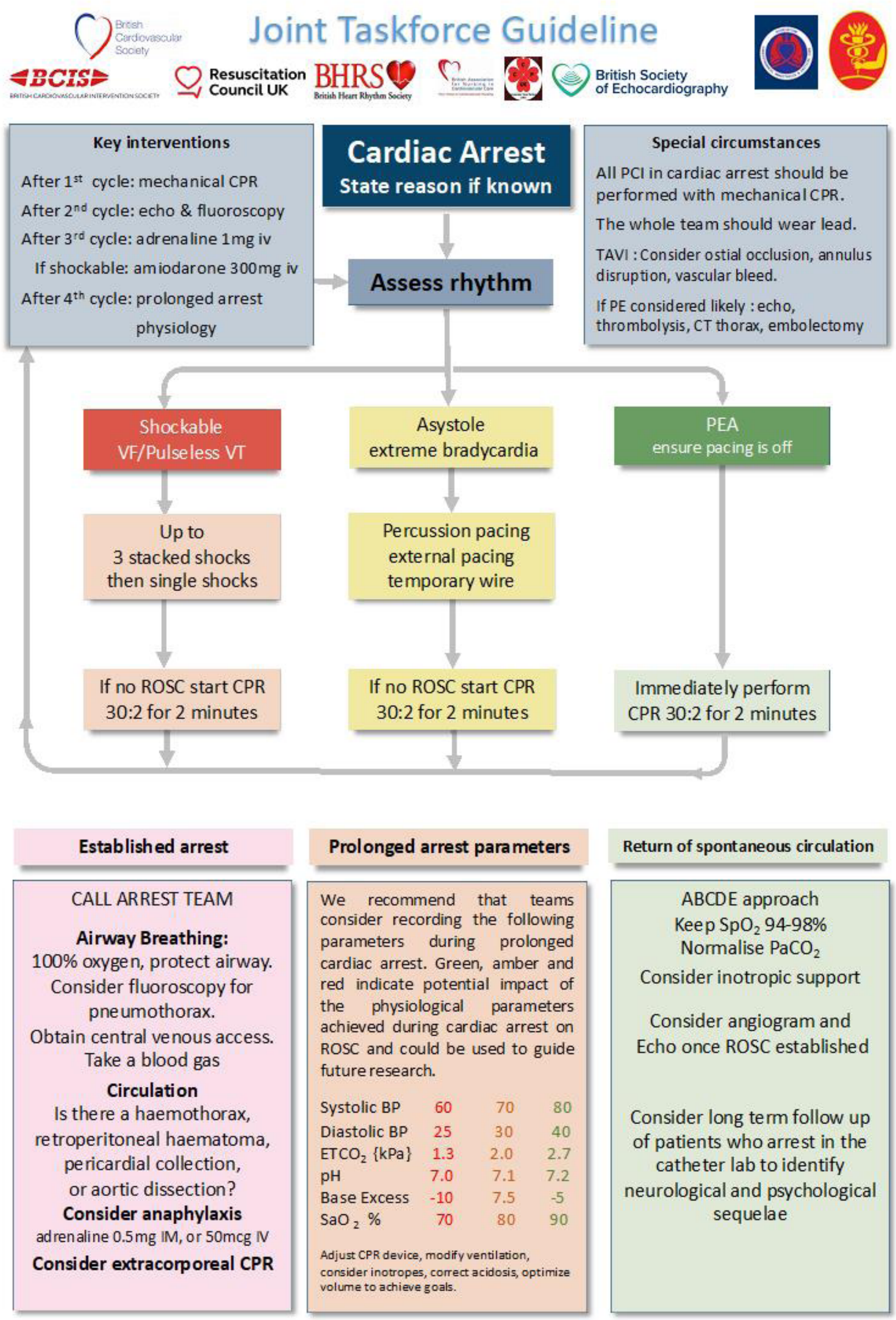

Figure 1 in the catheter laboratory. BCIS, British Cardiovascular Intervention Society; BHRS, British Heart Rhythm Society; CPR, cardiopulmonary resuscitation; PCI, percutaneous coronary intervention; PE, pulmonary embolus; PEA, pulseless electrical activity; ROSC, restoration of spontaneous circulation; TAVI, transcatheter aortic valve implantation; VF, ventricular fibrillation; VT, ventricular tachycardia.

In VF or pulseless VT, the pulse oximeter and arterial trace will confirm the absence of a cardiac output. A cardiac arrest should be called and the operator should tell the team if they know the reason for the arrest (eg, vessel dissection or occlu sion in PCI, occluded left main stem in TAVI or irritation of the ventricle in a pacing procedure for example). VF or VT is occasionally deliberately induced in EP labs and this should not

Temporary asystole or extreme bradycardia (<30/min) may occur and can be anticipated during manipulation of ventricular pacing leads or EP catheters. A cardiac arrest should be called when the rhythm disturbance is unexpected and or prolonged. The pulse oximetry and any arterial transduction will show

or temporary wire pacing may be attempted prior to chest

Many cases of PEA may be diagnosed by the absence of a pulsatile waveform on a continuous intra- sure display. Non- or minimal pulsatility of the arterial trace and pulse oximetry in the presence of continuing electrical activity confirms the diagnosis. The operator should call it a cardiac arrest and inform the laboratory team of the likely cause.

Pulseless VT can be mistaken for PEA. A regular rhythm above 140/min should be considered as pulseless VT if the arterial trace and pulse oximetry have minimal or absent pulsation and the

may be mistaken for PEA if the arterial trace is not being trans duced. It may be necessary to feel the pulse for 10 (and optimally) to perform a rapid echocardiogram to

Occasional patients will deteriorate in the catheter laboratory with support devices in place such as left ventricular assist device (LVAD), extra corporeal membrane oxygenation (ECMO) or Impella (Abiomed), where non- does not equate with

Should all members of the resuscitation team wear lead aprons?

All clinicians coming into an arrest in the catheter laboratory should wear lead aprons. Our protocol uses the members of the team present in the catheter laboratory in the initial stages of the arrest and, thus, it is strongly recommended that everyone entering the room should wear lead aprons as it is very likely that the cardiologist may need to perform fluoroscopy in many

We recommend that catheter laboratory team members are regu larly trained in basic airway management to ensure a patent airway and good oxygenation for all patients, to ensure that the anaesthetic team have adequate time to put on protective lead before entering the laboratory. We recommend that an individual in the catheter laboratory team is allocated to manage the personnel coming into the arrest. They will be required to assist these personnel to put on lead, and as they do this, they will be able to brief these clinicians as to the arrest situation in the catheter lab.

Catheter laboratories must also ensure that lead aprons in a range of sizes are immediately available for emergency team

	Class	Level
to entry. Advance provision should be made for enough lead aprons to be available for this situation.	IIa	C

Should we defibrillate before external chest compressions?

In 2020 ILCOR published a literature review on this subject and it was identified as a priority area for the Basic Life Support Taskforce. They found that in five randomised controlled trials (RCTs)

a specified period of chest compressions (typically 1.5–3

with interim brief CPR while the defibrillator was

CPR before defibrillation. The ERC 2021 guidelines do not recommend the routine delivery of a prespecified period of CPR before rhythm analysis and shock delivery, and recom mend shock delivery as soon as it can be applied. Deferring chest compressions until after shock delivery has been recommended in the ERC 2021 guidelines

such as after cardiac surgery and these now state: 'If a patient has a monitored and witnessed cardiac arrest (eg, in the catheter laboratory, coronary care unit, or other monitored critical care defibrillator is rapidly available: Confirm cardiac arrest and shout for help. If the initial rhythm is VF/pVT, give up to three quick successive (stacked) shocks. Rapidly check for a rhythm change and, if appropriate, ROSC after each defibrillation attempt. Start chest compressions

	Class	Level
without a cardiac output, external chest compressions may be deferred in order to perform up to three stacked shocks	IIa	A

prior to commencing external chest compressions?

Evidence was sought for the optimal number of attempts at external defibrillation for VF or pulseless VT prior to commencing external chest compressions. This has been subject to a literature review looking at the effectiveness of the numbers of defibrillation attempts in a range of scenarios including ICD insertions, electrophysiological studies, out- When the data from all 15 papers are combined, the average success rate of sequential shocks declines

14% for the third, and any subsequent shock will have less than a 10% chance of success. Thus, the likelihood of successful cardioversion declines dramatically from first to second shock

Our guideline seeks to place a mechanical CPR device on the patient early in the pathway and it is important to consider how we modify the protocol to allow this. First, it may be possible to assess the rhythm while the mechanical CPR is ongoing. Our patients often have multi- ead ECG monitoring, and sometimes intracardiac ECG monitoring, and thus where the team leader is satisfied that there has been no change from the shockable rhythm, there is no need to pause the CPR device every 2 n. If the team leader is uncertain then a pause should be performed every 2 n for rhythm assessment. As there is no risk to a rescuer, charging and administra tion of a shock may be performed while mechanical CPR is ongoing. Finally, if multiple shocks have failed to cardiovert the patient and it is clear that a coronary occlusion is the cause of the arrhythmia, then mechanical CPR should continue uninterrupted until coronary flow is restored.

	Class	Level
(VT), up to three stacked shocks should be given without intervening external chest compressions.	I	B
Thereafter, a single attempt at defibrillation, if required, is performed every 2	I	C
If the arrhythmia is due to an acute coronary artery occlusion, repeat	IIa	C
Shocks for known VF/VT should be administered while mechanical	I	C
pause the CPR device.	IIa	C

Should we perform pacing in patients who undergo an asystolic arrest in the catheter laboratory prior to external chest compressions?

In an asystolic arrest in a catheter laboratory there is the poten tial to rapidly restore cardiac output with pacing and, as this is a witnessed arrest, if pacing is performed immediately then potentially there will be an immediate restoration of a sponta neous circulation. Furthermore, in the literature review on the effectiveness of external chest compressions in the early stages of an arrest it was found that there was little evidence to suggest harm from delaying external chest compressions for a few minutes. Periods of asystole are not uncommon in pacing and electrophysiology (EP) laboratories and most cardiologists would use external, percussion or transvenous temporary wire pacing to address this as a routine part of their practice. We recommend that pacing should be attempted prior to the initia

Percussion pacing may initially be attempted (see the section below for further details). For external pacing the pacing pads should be applied, and the amplitude of the pacing quickly increased to regain an output. Only if capture is not obtained

external chest compressions be performed. If the cardiologist

to a conduction defect then transvenous pacing can be used if

	Class	Level
a rate of less than 30 bpm, external pacing or percussion pacing should be attempted prior to chest compressions.	IIa	C
	IIa	C

Interventions to address PEA

greatest number of patients possible may benefit from either immediate defibrillation or pacing prior to the institution of external cardiac compressions. In patients presenting with PEA efforts should be directed towards identifying the underlying causes and treating them rapidly. There are a number of possi bilities to consider that are relevant to the catheter laboratory:

Hypoxia: There is an airway and breathing protocol with a

Hypovolaemia: bleeding. Our recommendation ensures that the four most likely areas for bleeding in the catheter laboratory (haemothorax, retroperitoneal or vascular bleed, aortic dissec

Hypo/hyperkalaemia, H ion imbalance and electrolyte abnormalities are addressed by a recommendation to perform

Hypothermia is unusual in a catheter lab, other than following

Tension pneumothorax may arise during procedures requiring vascular access in the thorax. This is addressed in the airway and breathing protocol and by fluoroscopy.

Tamponade: Where tamponade is a possibility immediate echocardiography should be performed. The clinical sign most

generate a systolic blood pressure of 70

Toxins: One possible cause of a toxin-

eter laboratory is a drug error. We recommend that any syringe drivers or infusions should be stopped in the arrested patient to address this possibility. Careful consideration should also be

for supportive signs such as rash, wheeze or facial swelling. Our protocol recommends epinephrine 0.5

Thrombosis: coronary or pulmonary. In the catheter laboratory this would most commonly relate to acute coronary occlusion, either due to an acute myocardial infarction or a complication of

of the vessels by PCI. Pulmonary embolism causing an arrest is far less common. In an arrest situation it can be very difficult to diagnose but is suggested by disproportionate right ventricular distention. If suspected, then thrombolysis or thrombectomy

How deeply should we perform chest compressions?

The universal algorithm recommends compressing the chest to between 5 cm and 6 For those patients with an arterial trace being transduced, we recom mend 'titrating' chest compressions to achieve a systolic pressure of 70 Hg. This allows more gentle external compressions to be performed, potentially reducing the chance of compression related injury, while still producing effective cerebral perfusion. Furthermore, the inability to generate an acceptable systolic

	Class	Level
	IIa	C
	IIb	C

Should we perform a precordial thump?

be considered for termination of witnessed monitored unstable ventricular tachyarrhythmias when a defibrillator is not imme diately ready for use (Class IIb, level of evidence (LOE) B), but should not delay CPR and shock delivery'. ILCOR produced This documents that precordial thump is only effective in 2% of attempts and, in fact, rhythm deterioration is twice as common as successful cardio version. Thus, our protocol does not recommend a precordial thump. A defibrillator should be immediately at hand in every catheter laboratory, and this is much more likely to successfully

compressions in the catheter laboratory?

The AHA stated in 2010 that 'cough' CPR may be considered in settings such as the cardiac catheterisation laboratory for conscious, supine and monitored patients if the patient can be instructed and coached to cough forcefully every 1–3 s during the initial seconds of an arrhythmic cardiac arrest. It should not delay definitive treatment (Class IIb, LOE C). The AHA made no

The longest documented case of a patient maintaining their own spontaneous circulation is 90

able to maintain consciousness in a manner similar to the mechanism proposed for external CPR, namely a compression of the pulmonary vascular bed increasing the pressure in the left atrium then ventricle and allowing blood to flow across the There are case reports of its use for short periods of time in the catheter laboratory, including prior to defibril

severe bradycardia who are periarrest. ILCOR performed a

'We suggest cough CPR may only be considered as a temporising measure in an exceptional circumstance in a witnessed, moni setting (such as a cardiac catheterisation laboratory) if a non- hythm is recognised promptly before loss of consciousness (weak recommendation, very-

c arrest is very rapidly identified (while the patient is responsive), then it is reasonable to attempt to coach the patient to cough forcefully every 1–3 choose to try this. This should not delay the commencement of the cardiac arrest protocol including the application of pads and defibrillating or pacing if necessary. Staff should be ready to perform CPR if the patient stops following the command to cough, and the arterial trace should be observed to monitor the effectiveness of cough CPR.

	Class	Level
Vigorous cough cardiopulmonary resuscitation (CPR) every . It is likely to be most	IIb	C

Percussion (fist) pacing as an alternative to CPR in the catheter laboratory

ILCOR performed a systematic review on this subject in 2021. The total number of cases reported in the literature is around 170 patients and in the largest series of 100 patients, 69 of these maintained consciousness and 90 had percussion pacing as an alternative to CPR.

In a study performed in 1978

authors found reliable electrical impulses could be reproduced for up to 6 the left lower sternum was struck with

fist pacing may only be considered as a temporising measure in an exceptional circumstance in a witnessed, monitored, in-pital setting (such as a cardiac catheterisation laboratory) if a hythm is recognised promptly before loss of

The catheterisation laboratory is a highly monitored environment where bradycardia and asystole are common. There have been no studies comparing CPR to percussion pacing directly but

monitoring, we recommend that this could be a useful temporising method in the catheterisation laboratory, while preparations are made for external pacing or a temporary wire or the

	Class	Level
), by a continuous arterial tracing, pulse oximetry and ECG.	IIb	C
Percussion pacing should be performed at a rate of 50–70 used to strike the chest from 20–30 , in order to mechanically increase the right atrial pressure, if measured, by 15–20	IIb	C

Active pad compression for defibrillation

In atrial fibrillation there are papers including the Ottowa AF and the 2014 AHA guidelines for the management of patients with atrial fibrillation using paddles to provide manual compression over the defibrillator pads as a method of increasing the success of cardioversion.

was by Kerber in 1981 looking at 44 cardioversion patients, although, interestingly, the only part of this paper that actually looked at active compression was a subreport of four dogs who were cardioverted with or without active compression. in 1988 reported a 13% reduction in impedance with active compression when uniphasic defibrillation was being performed in 28 patients and a similar result was found by in 2016 with 11 participants where they concluded

series, as well as a trial of cardioversion in atrial fibrillation, that active compression of the defibrillation pads using disconnected defibrillation paddles reduces intrathoracic impedance and improves shock efficacy. In the absence of any studies in ventricular arrhythmias in humans the routine use of active compression during defibrillation is not recommended. However, the use of disconnected defibrillation paddles to apply external compression to defibrillation pads may be considered in patients with arrhythmias refractory to cardioversion particularly where

either in an anterior- an anterior-		
cardioversion have failed, an expert clinician who feels that increased impedance may be a factor, such as in high body mass index (BMI), may elect available to provide the compression.		

Does epinephrine improve outcomes in resuscitation in the catheter laboratory?

ILCOR in 2015 reviewed the literature with regard to epinephrine including a large RCT by Olasveengen where ambulances were randomised to Group 1: CPR and defibrillation with iv cannulation and usual resuscitation medications versus Group 2: CPR and defibrillation alone. This RCT showed reduced survival to hospital discharge in Group 1 and this was felt to be due to the ineffectiveness of the drugs and also the delay in CPR in order to cannulate and administer the drugs. This paper, and a more recent meta- (demonstrating no benefit of epinephrine in cardiac arrest) led ILCOR to write: 'despite the widespread use of epinephrine during resuscitation, and several studies involving vasopressin, there is no placebo controlled study that shows that the routine use of any vasopressor at any stage during human cardiac arrest increases survival to hospital discharge. Current evidence is insufficient to support or refute the routine use of any particular drug or sequence of drugs. Despite the lack of human data, the use of epinephrine is still

The PARAMEDIC-

arrest situation across five ambulance services in the UK to receive

containing 0.9% saline. The mean time for the ambulance to

tion was 13 after arrival. There was a large increase in the

in the epinephrine arm (36% vs 11%), as well as the number who were transferred to hospital (50% vs 30%). The primary outcome measure was survival at 30 days and this was 3.2% in the epinephrine group and 2.4% in the placebo group which was significant, but the number of survivors with severe neurological impairment was 31% in the epinephrine group versus 18% in the control group, and thus the trial was negative in terms of survival with favourable neurological outcome (2.2% vs 1.9%). The triallists concluded that epinephrine significantly improved

led only to a greater proportion surviving with severe neurolog ical disability.

In the light of this important study, we suggest that the current

that it is unlikely to harm the patient and may be beneficial. We recommend that intrave is given after the third cycle. It may be acceptable to administer smaller doses of epinephrine if a senior clinician feels that there may be reactive hypertension on ROSC.

istration of epinephrine in cases of a non- rhythm. Current recommendations from the ERC are to give epinephrine but they do caveat this by saying that 'exceptions may exist where a clear reversible cause

laboratory there are reversible causes that should be addressed, and for this reason the group concluded that we should recom mend administering epinephrine at the same time as in a shock able rhythm to allow time for reversible causes to be addressed.

	Class	Level
We recommend that for patients who arrest in a catheter	I	A
	I	A

Table 1

Physiological parameters of interest

The following parameters are suggested to encourage data collection and stimulate research in a cardiac arrest management. It should be noted that they are not known markers of improved clinical outcome.

Parameter of interest	**Parameter targets**
tidal CO	
tidal CO (kPa)	

Green, amber and red indicate potential impact of the physiological parameters achieved

guide future research. Clinical decisions regarding cessation of resuscitation should not be based only on these parameters.

	Class	Level
We recommend that for patients who arrest with a non-	IIa	C

Waveform capnography in cardiac arrest

We recommend that waveform capnography is used for patients in established cardiac arrest. Not only does this prove that the airway is patent, and that there is reasonable air entry to allow the exchange of CO , but more importantly the level of exhaled correlates with the cardiac output. Capnography can be used as a prognostic guide to the likely result of prolonged resus citation. An end-

good prognostic indicator whereas an end-

a) indicates a poor prognosis and may be used to indicate that further treatment is likely to be futile or that

Goal-directed management during prolonged cardiac arrest in the catheter laboratory

A number of physiological parameters are associated with higher rates of ROSC. This has led to the hypothesis that higher rates of ROSC and better clinical outcomes might be achieved by goal- rected resuscitation techniques. This may be particularly relevant to the management of cardiac arrest in the catheter laboratory where resuscitation attempts may be prolonged and invasive monitoring is routine. Physiological parameters of interest based on our literature review on this topic are listed in table . This concept was investigated in a series of 10 patients who underwent mechanical CPR and PCI to treat prolonged cardiac arrest in the catheter labo ratory. The average time of mechanical CPR was 43 n. Systolic blood pressures above 70 nd diastolic blood pressures above ere targeted. A pigtail catheter was inserted into the right atrium via the femoral vein at the interventionists discretion to monitor CVP and to administer vasoactive drugs. The investigators aimed to keep the CVP below 25 Hg. If this was not achieved, echocardiography was performed to exclude cardiac tamponade, the mechanical CPR device was repositioned, and inotropes or vaso constrictors were initiated. End- dal CO was measured following insertion of an endotracheal tube or a supraglottic airway with a target of Hg (>2 Pa). The SpO was kept above 80%, and arterial blood gas measurement was used to guide 'normo' ventilation. Cerebral oximetry was also monitored. Vasoconstrictor infusions were used in favour of epinephrine boluses. For patients in VF, attention was directed towards opening the acutely occluded coronary artery in favour of repeated attempts at defibrillation. The protocol was simulated in training prior to its institution. Early expe rience identified difficulties measuring all of the parameters every n during ongoing cardiac arrest. When the parameters were measured successfully, they regularly identified patients whose vital parameters were suboptimal.

In the AHA 'get with the guidelines registry' of 3023 moni tored cardiac arrests and 6064 unmonitored in-

chance of survival based mostly on blood pressure and tidal CO

above 20

sure above 25 Hg in their consensus statement on improving

A group in Greece wrote a discussion document proposing the 'PERSEUS' protocol in 2019 aimed at prolonged physiological monitoring of patients in cardiac arrest.

mechanical CPR, and ventilating the patient with positive end expiratory pressure (PEEP) of zero, respiratory rate of 10 per min, tidal volume 6 100% oxygen, inspiration:expira tion ratio 1:2. In a previous observational study they had found higher airway pressure was associated with better outcomes, with a pressure of 40–45

output and discuss how positive pressure ventilation may be used to augment cardiac output during chest compressions.

the CVP below 25

low, a straight leg raise should be performed to assess volume status and then fluid be given as indicated. They suggested using optimal positioning of the mechanical CPR device and epineph rine infusions to keep the diastolic blood pressure above 40

associated with a lower rate of survival. In particular, patients without ROSC had a mean pH of 7.11, pCO of 9.7 a, base excess of −7 mmol/L, potassium of 4.5 mmol/L and a lactate

A meta- nalysis of goal- rected resuscitation identified mainly animal studies but did conclude that goal- directed CPR may be superior to standard CPR, especially when end- dal CO and blood pressure management were targeted. It is important to emphasise that a low end- dal CO may reflect inadequate ventilation rather than low cardiac output, especially when a supraglottic airway is used, because of the higher airway pressures required during chest compressions and steps should be taken in these cases to place an endotracheal tube as soon as it is safe to do so.

Monitoring of the CVP allows an estimate of coronary perfu sion pressure by subtracting the diastolic arterial pressure from the CVP. Ideally it should be kept above 20

he catheter laboratory is a unique environment in which phys iological parameters can be accurately monitored during circu latory arrest. These parameters can be used to assess the effect of interventions such as the adjustment of cardiac massage technique, intravenous administration of vasoactive medications, correction of acidosis, electrolytes, and volume status, and less conventional treatments such as head- p CPR, while prolonged revascularisation attempts are ongoing or preparation is made for ECPR. Whether or not goal- rected resuscitation improves clinical outcomes, or even increases rates of ROSC, is not yet clear so firm recommendations for setting physiological parameter targets during cardiac arrest cannot be made. Nevertheless, we recommend that teams consider recording physiological parameters during prolonged cardiac arrest table). Green, amber and red indicate the potential impact of the physiological parameters achieved during cardiac arrest on ROSC and could be used to guide future research. Clinical decisions regarding cessation of resuscitation should not be based only on these parameters.

	Class	Level
We recommend that physiological parameters are recorded at regular intervals during cardiac arrest in the catheter laboratory	IIb	C

Is amiodarone of use in a VF arrest in the catheter laboratory?

We sought evidence as to whether amiodarone or lidocaine may be useful for VF/pulseless VT. There is good evidence in support each demon

sion of about 10%. It must be noted that these studies are all in

tory VF/VT followed by an infusion of 900 over 24 hours. Lidocaine 1 used as an alternative and may have a similar efficacy.

	Class	Level
(VT) without a cardiac output, a bolus of 300	I	A

The use of echocardiography during cardiac arrest

Echocardiography can help to identify the cause for the arrest and should be performed rapidly as an integral part of the resus citation. It is important to exclude tamponade early in the resus citative process and also to repeat the echo in a prolonged arrest if the effectiveness of CPR diminishes abruptly as this may indi cate tamponade secondary to external cardiac massage or delayed onset of tamponade. Echocardiography has also been shown to

probe in place this has advantages compared with transthoracic in that it does not require interruptions of CPR, can be performed continuously with better images, can be used to identify ROSC quickly, to look for dissection of the

wires or the initiation of ECPR. It is also better at monitoring the effectiveness of prolonged mechanical CPR. In addition, there may be clinicians experienced in its use available in the catheter laboratory. Thus, if it is in place already it is preferred to transthoracic echocardiography, and if it is not in place then it should be considered, especially if prolonged arrest management is being planned, allowing for the risk of oesophageal damage in

	Class	Level
We recommend that echocardiography is performed early after cardiac arrest, particularly if immediate interventions, such as defibrillation or pacing, have failed to restore cardiac output. Transthoracic echocardiography is the most readily available modality and should If a transoesophageal echo (TOE) probe is in place, In a prolonged arrest, teams may consider the placement of a TOE probe.	IIa	B

Fluoroscopy in order to identify a pneumothorax in an arrest in the catheter laboratory

A literature review was performed in an attempt to find cases of pneumothorax identified by fluoroscopy in a catheter laboratory and to gain an understanding of the incidence of pneumothorax causing cardiac arrest, particularly after pacing procedures, or transaxillary, transcarotid or subclavian arterial approaches.

Pneumothorax is not uncommon after attempted vessel punc

If a pneumothorax is suspected it is straightforward to diag nose in the catheter laboratory by fluoroscopy, which has also

In a cardiac arrest, one potential cause could be pneumo thorax. Since there is immediate access to fluoroscopy, it is recommended that in a cardiac arrest with no clear cause iden tified, and especially if the patient is undergoing an intervention that is high risk such as pacemaker or ICD insertion, fluoroscopy is performed to exclude pneumothorax as a cause.

	Class	Level
If a patient arrests without a clear cause, especially in a procedure that is high risk for a pneumothorax, (pacemaker or defibrillator insertion), it is recommended that fluoroscopy be used to investigate this as a cause.	IIa	C

How should the team balance chest compressions with attempts at percutaneous intervention in a cardiac arrest?

Interventions on the coronary arteries can be associated with

perforation. In the majority of these circumstances, a key part of the ongoing resuscitation effort will involve a further interven tion to treat or reverse the underlying cause. In order to preserve cerebral perfusion until a spontaneous circulation is restored, external cardiac massage is required. Manual cardiac massage cannot be achieved at the same time as fluoroscopy due to radi ation exposure for the rescuer and therefore a balance must be struck between the interventionalist and those performing

The AHA, the ERC and the Australian Guidelines all address the issue of external cardiac massage in the catheter laboratory.

the ERC recommend that external cardiac massage should not be interrupted for angiography and the Australian Guidelines discuss the tension between the rescuers performing external CPR and the interventionalist wanting to continue with angi ography. These statements have not translated into an agreed

We strongly recommend using only mechanical CPR devices to administer CPR while undergoing PCI during an arrest. It is reasonable to pause manual CPR in order to perform angiog raphy to search for a cause for the arrest, but subsequent PCI should be performed with mechanical CPR.

	Class	Level
arrest, this should be performed after mechanical	I	C
	IIb	C

The use of mechanical CPR has been extensively investigated in at least nine randomised trials with over 12

of-hospital and in-hospital arrest. Several meta-

The AHA reviewed the feasibility of using mechanical CPR devices during PCI and identified papers where feasibility has been demonstrated in both animal and human[63–66] studies. No compar ative studies have examined the use of mechanical CPR devices compared with manual chest compressions during PCI procedures although, due to the inherent need to cease manual compressions during fluoroscopy, there is a clear benefit for mechanical CPR.

the use of mechanical CPR devices to facilitate prolonged resus citation in patients who have a cardiac arrest during PCI. One study demonstrated that the use of a mechanical CPR device for cardiac arrest during PCI was feasible; however, no patients survived to hospital discharge. Other studies have reported good patient outcomes, including ROSC and survival to discharge with good functional outcome.

time required to perform PCI with a mechanical CPR device was min to 90 which high lights further the importance of a protocol that allows prolonged

We are therefore strongly of the view that mechanical CPR devices are of major benefit to patients in the specialist envi ronment of the catheter laboratory, for liberating rescuers from performing manual CPR and for the ability to perform uninterrupted CPR for at least 30

Figure). In addition, we strongly advocate the immediate availability of these devices in the catheter laboratory and regular team- training in order to be able to place these

	Class	Level
resuscitating the patient. We recommend that mechanical	I	A
We recommend that all catheter laboratories have mechanical CPR immediately available in the catheter	I	C

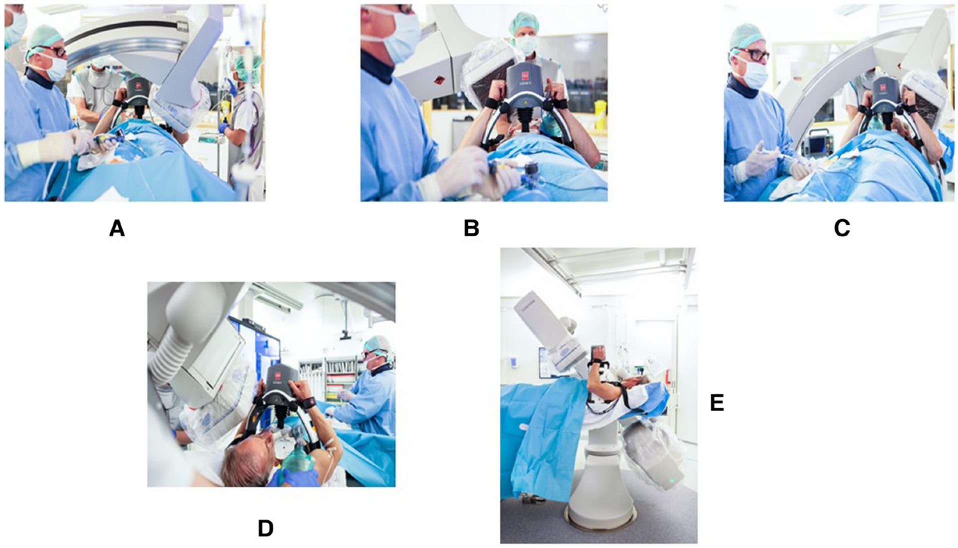

Figure 2 rdiac massage device in place. (A) Right posterior oblique; (B) Left anterior oblique; (C) Right anterior oblique; (D) Straight cranial; (E) Straight caudal (with permission from Stryker Corporation).

	Class	Level
We recommend that teams undergo regular group training	I	C

ECPR in the catheter laboratory

The AHA and the ERC both recommend the use of ECMO to provide ECPR. The AHA state that 'rapid initiation of eCPR or cardiopulmonary bypass is associated with good patient outcomes in patients with haemodynamic collapse and cardiac

feasible and associated with good outcomes when used as a bridge to coronary artery bypass grafting' (AHA Class IIb, LOE C). The ERC are more equivocal, stating that very low quality evidence suggests that the use of extracorporeal life support can

area called the ARREST Trial was stopped early due to the highly significant effects in favour of ECMO in out of hospital cardiac arrest (OHCA). Thirty patients were randomised and there were six survivors in the ECMO group compared with only one in Furthermore, there are many case series reporting the efficacy of extracorporeal cardiopulmonary

reported in 2011 on the use of extracorporeal

including cardiac arrest and cardiogenic shock in the catheter laboratory. The survival to discharge was 71%. Van den Brink reported the use of extracorporeal cardiopulmonary bypass in 12 patients of whom 11 were in cardiac arrest with

Extracorporeal Life Support Organisation has published a position paper in 2018, advocating ECMO in arrests of longer

	Class	Level
use if it is available.	IIa	B

IABP insertion in the arrest situation

The evidence for the insertion of an IABP in an arrest situation

and concluded that while IABP counterpulsation increases coronary perfusion, decreases myocardial oxygen demand and improves haemodynamics in cardiogenic shock states, it is not associated with improved patient survival. They state that the role of IABP in patients who have a cardiac arrest in the cathe

The IABP- rial which randomised nearly 600 patients who were in shock from an acute myocardial infarc tion did not find an improvement in the 30- This landmark study followed 13 RCTs

which were all unable to detect a significant improvement in other small improvements were some It must be noted that although these studies were in patients with an acute myocardial infarction (rather than patients in cardiac arrest in a catheter laboratory) the IABP- rial has led to a significant reduction in the use of IABP

A further small RCT looking at IABP versus control in patients who suffered a cardiac arrest with an acute coronary syndrome

There are few studies looking at the insertion of IABPs in the arrest situation.[92,93] Without a spontaneous circulation to trigger the IABP, counterpulsation would be unlikely to be successful. Thus, it is concluded that there is no indication to

eter laboratory.

	Class	Level
The insertion of an intra-		

Is an Impella pump useful in an arrest?

The ERC in 2015 stated in their section on cardiac arrest in

circulatory support with the Impella pump only during cardiac

provide circulatory support while performing rescue procedures but require further evaluation. They provided a single reference which was a case series of eight patients who had an Impella device in an arrest, of whom four survived to hospital discharge. We identified a further paper documenting

There have been case series and cohort studies of the use of the Impella in cardiogenic shock in adults and children and in and there is an interesting ongoing RCT

The 2021 joint ERC and European Society of Intensive Care medicine guidelines for postresuscitation care state that 'the evidence about which type of mechanical device is superior appears inconclusive and thus their use should be decided on a

	Class	Level
The use of an Impella is not routinely recommended in		

The identification and treatment of pericardial tamponade

Sample database from 2009 to 2013 which covers around 90% of all patients in the USA. They document 64

17% were in PCI cases, 13% in EP procedures and 14% in struc

all types of catheter laboratory interventions. database study they were unable to comment on the procedural success rate, although the inpatient mortality in the database overall was around one in four.

Tsang *et al* documented a 21- experience with a thou sand pericardiocentesis procedures at the Mayo clinic, including many patients with perforation in the catheter laboratory. They report a 97% procedural success for this procedure in all settings with only a 2% major complication rate. They also reported that they saw a significant increase in the rate that clinicians left a

confirmed these findings in a report of nearly 300

with approximately 40 during PCI. They reported a 99% proce

A UK observational study of 270 329 PCI procedures in the context of acute coronary syndromes describes 1013 coronary perforations (0.37%). Importantly, the adjusted ORs for all clinical outcomes were adversely affected by coronary perfora tion. The conclusion was 'Coronary perforation is an infrequent event during ACS- but is closely associated with adverse clin

The ESC position statement on the urgent management of cardiac tamponade gives a class I indication for pericardio

where possible although fluoroscopic guidance is an acceptable alternative. If unsuccessful, surgical drainage is recommended.

immediate access to an echo machine in order to be able to confirm or exclude tamponade in an emergency. All cardiologists

pericardiocentesis techniques, and all catheter labs should have a dedicated and easily accessible pericardiocentesis kit, which the team are familiar with. The emergency procedures for peri cardiocentesis should be familiar to all catheter laboratory staff. The pericardiocentesis/perforation kit should be stored together and include drainage equipment, coils and covered stents. There should be an agreed unit protocol as to the method of distal embolisation technique as a wide variety of options are available.

In all cases of pericardial collection, repeat TTE should be performed within 2 hours. This is particularly important in the case of distal wire perforations and any case in which a perforation has apparently sealed spontaneously.

	Class	Level
Pericardiocentesis should be performed for all patients with echocardiographic or fluoroscopic guidance. Surgical drainage successful in relieving the tamponade.	I	B
An echocardiography machine should be immediately available	I	C
We recommend that a repeat echocardiogram is performed to	IIa	C

Treatment of pericardial tamponade if pericardiocentesis fails

database reported a 0.3% perforation rate with PCI. This

Thus, there are roughly 250 coronary perforations per year with

per year in the UK who require emergency surgery after coro

This number is likely to have increased since 2013. Further more, this database does not include pacing procedures, EP or structural heart procedures. Thirty- in a unit without surgical cover (589

compared with 997 in units with cover). Coronary perforations can be classified using the Ellis Classification both in the arrest according to the significance of the defect created in the artery.

With regard to the perforation of cardiac chambers from non- s, the National Cardiovascular Data Registry in the USA documented 625 cardiac perforations in a 5-

of an ICD. The BHRS has provided detailed guidance in their 2016 document entitled 'Standards for Interventional Electro

We recommend that for coronary perforations consideration be given to heparin and antiplatelet reversal, a decision that must be balanced against the risk of producing stent thrombosis. An

We recommend there should be on-
rience with covered stents, embolisation coils and the ability to perform distal embolisation. There should be an agreed unit protocol as to the method of distal embolisation technique as a

For perforation of cardiac chambers we also recommend consid eration of reversal of heparin, calling for senior colleague assistance, where relevant withdrawal of the lead or wire from the perforation and echocardiographic monitoring for a tamponade.

	Class	Level
For coronary perforations, consideration should be given to reversal of anticoagulants, antiplatelet medications and glycoprotein IIb/IIIA inhibitors and an activated clotting time (ACT) should be performed.	IIb	C
There should be on- covered stents, embolisation coils and the ability to perform distal embolisation. There should be an agreed unit protocol variety of options are available.	IIa	C
For all cardiac perforations, even if the patient seems stable, a decision must be taken as to whether cardiac surgical colleagues should be consulted. The threshold for surgical discussion should be low. Failure to stop the underlying	IIa	C

Surgical support

There should be access to emergency cardiothoracic surgery for all patients who have suffered a tamponade in the catheter labo ratory. In units without cardiac surgical cover, an agreed written protocol must be in place in order to ensure that timely relief of a tamponade is possible. The time taken for a patient to ster notomy should be of a similar order to that possible with on-

Options to achieve this may include rapid transfer to the

surgeon travels to the local centre. We recommend that these protocols be documented and tested regularly to ensure equi table availability of potentially life-

We furthermore recommend the notification of the on- all surgical team for all coronary perforations that cannot be sealed via percutaneous techniques, and all cardiac chamber perforations requiring a pericardiocentesis drain, even if they seem stable, so that the most appropriate management strategy can be agreed.

	Class	Level
In units without cardiac surgical cover, an agreed written surgical relief of a tamponade is possible. The time taken	IIa	C

We identified papers relevant to the management of either confirmed or suspected pulmonary embolus (PE) in cardiac arrest. In addition, the ESC have guidance on the treatment of and the AHA and ERC both give recommendations in this

It may be difficult to determine PE as the cause of the cardiac arrest teams have been able to iden Teams may identify factors precipitating the cardiac arrest before the actual arrest which may include a high- history such as malignancy, previous PEs or recent surgery, they may identify symptoms such as dyspnoea, tachycardia and chest pain, and there maybe signs on ECG or

Once the arrest has occurred, the arrest rhythm is more commonly PEA (63%) versus only 5% in VF.
raphy during the cardiac arrest may identify a distended right ventricle with a flattened interventricular septum in cases of PE large enough to precipitate arrest, although right ventricular

In terms of the treatment of the PE in the cardiac arrest *et al* published a meta- in 2006 of eight papers that demonstrated that thrombolytics administered during CPR did improve survival, although inevitably there was also an increase in bleeding complications. In an RCT of 1000

bolytic therapy, no improvement in survival was seen but the percentage of patients who actually had PE may have been low in this study.

The ERC recommend the use of fibrinolytics for patients suspected of arresting secondary to a massive pulmonary They also recommend that CPR should then

device may therefore be required for this. In addition, if there is return of spontaneous circulation then particular attention should be paid to identification of bleeding complications thereafter and in centres where this is available ECPR could be

The AHA gives a class IIb indication for echocardiography during cardiac arrest stating that 'if a qualified sonographer is present and use of ultrasound does not interfere with the stan dard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation'. The AHA recommend thrombolysis with a class IIb strength of recommendation in addition to systemic anticoagulation. The

thrombectomy although many units would not have access to this as it requires specialist equipment. One case series reported a successful outcome of percutaneous mechanical thrombectomy

We also discussed whether in an arrest where PE is suspected in the catheter laboratory pulmonary angiography should be performed, but technically this was felt to be difficult to

	Class	Level
in the catheter laboratory, we recommend thrombolysis and systemic anticoagulation. Cardiopulmonary resuscitation assist in making this diagnosis.	IIb	B

Return of spontaneous circulation

Once there has been a return of spontaneous circulation a full airway, breathing, circulation examination should be performed. Angiography and echocardiography should be considered where appropriate. If the patient has not neurologically recovered suffi ciently or their gas exchange is unfavourable it is often safer to intubate and ventilate. Appropriate vascular access with a central line and an arterial line will allow cardiac monitoring and vaso active drug use as necessary. It is important that such patients are treated in an intensive care area environment if ventilated and at least a high care area otherwise. If there has been a prolonged

extensively investigated especially in out-
and may help a patient who has had a prolonged arrest. However

and the target temperature has not been established and there

Perhaps more importantly the possible longer-

If the patient makes a good physical recovery, they should be fully counselled as to the events that occurred in the arrest and consideration of additional or prolonged follow-
given to make sure that they suffer no neurological or psycho logical sequelae. The ERC and the European Society of Intensive Care Medicine have written detailed guidance in 2021 for post-resuscitation care which addresses many of these issues and in addition to this there is excellent patient support at the website www.suddencardiacarrest.org.

THE OPTIMAL CONFIGURATION FOR THE CARDIAC ARREST

In order to carry out emergency protocols efficiently, whether

vital for all team members to know their roles and responsibili ties. There may be a wide variety of staff numbers and skill mixes available in the catheter laboratory area depending on the size

there will clearly also have to be some flexibility and also addi tional roles that might be allocated, but we propose these six key roles to allow a structure for people to work towards (Figure
In addition, it is optimal that the staff members will know in advance the role that they would be expected to take in an emer gency, and that this could be documented on a communication

The operator

While the cardiologist takes the lead in the catheter lab, the main aim of our protocols is to free this person up of responsibility for resuscitation in the cardiac arrest or the emergency situation. The cardiologist should stay scrubbed at the side of the patient.

must declare this early to the team but thereafter an emergency

The cardiologist is best placed to perform the specialist inter

addressing resuscitation via the team leader.

Role 1: The emergency leader

We recommend that someone other than the operating cardiolo gist organise the team to achieve the best outcome for the patient. We do not mandate who this person should be in terms of their discipline or qualifications, and in fact we are of the opinion that everyone who works in a catheter laboratory should be trained to be able to carry out each of the six key roles, although often in the day there might be another senior cardiologist who will be

The role is to coordinate the protocols highlighted above as the leader of the group addressing all the components of the arrest response. The leader is encouraged to have the protocol to hand on a flip chart or on a poster.

The emergency leader must make sure personnel are allocated to all required roles and will also allocate tasks to additional

Role 2: Airway and breathing

If there is any acute emergency and especially in an arrest, the scrubbed personnel will be dealing with the circulation, so

Figure 3 he six key roles. BCIS, British Cardiovascular Intervention Society; BHRS, British Heart Rhythm Society; CPR, cardiopulmonary resuscitation.

another member of staff should go straight to the head of the patient to take responsibility for airway and ventilation. For a

valve/mask at 100% oxygen and place this on the patient's face and attempt to ventilate the patient. If they are successful, then the chest will rise on both sides, and water vapour may be seen in the mask. If they are unsuccessful then an airway obstruction issue must be considered. Attempt airway manoeu vres—jaw thrust, chin lift, Guedel airway and perhaps ask another person to help with squeezing the bag so you can use two hands to form a good seal around the patient's nose and mouth. We do not recommend that staff who are not fully trained in the technique attempt intubation. In most instances simple airway manoeuvres and airway adjuncts will suffice. A

Once air entry is established in an arrest you must coordinate 30:2 with the person performing massage or the automated CPR device. Your role also requires you to feel the trachea to see if it is central or displaced and then ask everyone to stop massage and bag forcefully while listening bilaterally to see if you can hear a

It is mandatory to perform these assessments in every critically ill catheter laboratory patient if you do not know the cause of their deterioration, and you must communicate that you have done this to the team leader. It is not always easy to, but if you are getting air entry from bagging but it is more difficult than

vigorously but cannot hear breath sounds on one side then a pneumothorax or haemothorax should be suspected and this must be communicated to the team leader. We also recommend that fluoroscopy is performed for every arrested patient without

If a tension pneumothorax is suspected, for example, oxygen saturations dropping and the patient complaining of being short

followed by a drain or a thoracostomy.

Role 3: Defibrillation and pacing

We recommend that a single person is always allocated to this role and stays beside the defibrillator at all times, even if the rhythm is not shockable. The person fulfilling role 3 should place pads on the patient wherever it is most convenient. Often they will be draped and therefore access will be limited but this will have been practised in simulation so should not be an issue. Anterior- position, an anterior-

hythm is shockable we recommend immediate shocks. Once the first shock has been delivered, external cardiac massage should not be recommenced, but the rhythm assessed while the defibrillator is being charged for the next shock. If there is no ROSC and the rhythm remains shockable, up to two further shocks should be delivered in rapid succession. The defibrillator operator is responsible for communicating to the team when the defibrillator is charging and before

If the third shock fails then further shocks may be given at

a timer, so the defibrillator operator is often the best person

Role 3 is also important in the two other rhythm disturbances.

pacing may rapidly resolve the situation. We recommend that percussion pacing is attempted while pads are placed on

pace and sense from the same pads and thus it is mandatory that ECG leads are placed on the patient and connected to the defibrillator prior to attempting external pacing. We recom mend that external cardiac massage is withheld until the pacing is attempted. When the pacing is activated on the defibrillator it usually defaults to the minimum amplitude, and therefore

not achieved at maximum amplitude then it is unlikely to work unless the pads are poorly placed and the attempt can cease. If it is felt likely that the asystole or extreme bradycardia could be

were unsuccessful then the final option would be a temporary

Defibrillation is not required in PEA arrest but the defibrillator operator should ensure that underlying VF or asystole is not mistaken for PEA in patients with either a temporary or perma nent pacemaker in place. We are aware of three cases when this occurred and although rare, if there is a temporary wire with pacing this can be paused to check, or if there is a permanent pacemaker then a relatively narrow QRS complex with a regular

Role 4: Manual chest compressions

One person should be allocated to perform CPR. If there are very limited numbers of people in the room at night then either the cardiologist or the scrub nurse could do this but it is an

been administered or the external pacing has been commenced,

performing CPR will most likely need to be on the opposite side of the table to the cardiologist, and if the table is fairly high they may need a step to stand on. Hands should be linked together and elbow straight and CPR is performed on the lower half of

	Class	Level
Ventricular fibrillation (VF), pulseless ventricular tachycardia). There is no need to routinely look, listen and feel for 10	I	C
then either look, listen and feel or use echocardiography to	IIa	C
respond to percussion, external or temporary wire pacing and thus we recommend following the asystole pathway.	I	C
ay for VF/pulseless VT as this may	IIa	C

The general algorithm recommends a depth of 5–6

compressing adequately, but if your patient has an arterial line in place then in fact this can function as a direct measure of the quality of your CPR. In this situation you should compress the chest hard enough that you achieve a systolic pressure of is also important to note that if you have a well-

can but you are unable to achieve a systolic pressure of 70

there is a mechanical cause to the arrest such as a tamponade or a bleed, as it indicates either that the heart is compressed by tamponade and cannot fill with blood to eject, or that the heart is empty of blood due to blood loss. The inability to maintain a systolic pressure of above 70

Role 5: Mechanical CPR, drugs, timing and vascular access

Some smaller centres or primary PCI sites in the middle of the night will not have six people in the catheter laboratory, but in the day-

cient numbers of people immediately available. Therefore we considered protocols from four to eight allocated members and propose six roles here The role of having a person in charge of mechanical CPR, drug administration, vascular access and timing we would regard as highly desirable assuming there is adequate personnel available. This person's first role would be to immediately obtain the mechanical CPR device, turn it on and prepare it for placement after the first cycle of CPR. Then this person can stand by the person allocated to airway and breathing

There are some key drugs that this person would need to have immediately available. Epinephrine in an arrest should be given

after the third cycle in the protocol for all arrest rhythms. It should then be given every other cycle which is again in line with the general algorithm unless the arrest is likely to be prolonged in which case the team leader will determine whether an infusion or a vasoconstrictor may be better.

If the arrest is due to a resolvable mechanical issue such as

the epinephrine to avoid its proarrhythmic effects and potential hypertension once the tamponade is removed which may risk further bleeding from the vessel that caused the tamponade in

shown to have a 10% increased change of defibrillation being successful in several RCTs and is recommended in all algorithms

The third drug to mention in cardiac arrests is atropine. It was removed from the universal algorithm in 2015 due to lack of efficacy in the arrest situation and therefore it does not appear in our arrest algorithm. It is important to remember that it is still an important medication in bradycardia with a pulse when the

Finally it is useful to mention that in cases of oversedation naloxone at a dose of 400 mcg repeated every 3

immediately reverse the effects of morphine and fentanyl, and intravenous flumazenil at 200 mcg repeated every 30

equally effect a rapid reversal of midazolam and other benzodiazepines and that in a prolonged arrest infusions

Role 6: Resource coordinator

There are often many members of the team available to help

that there has to be a great deal of organisation behind the actual arrest or acute emergency.

dinating everything in the room but there have to be advanced lines of communication between the catheter lab, the coronary

important to have a specific allocated role. If other personnel arrive, such as anaesthetists and surgeons then the resource coor

must be worn) and while they are being put on then they can brief the person as to the case and what the nature of the emer gency is. They may also be able to direct them to look at the

rather than going into the room and immediately talking to the

It is possible that this role may fall to the radiographer who is a key member of the team and will most usually be at the foot

TEAM TRAINING AND VISUAL AIDS

The ERC 2021 guidelines strongly recommended that all clini cians and staff who work in the catheter laboratory be adequately trained in protocols specific to this environement. The ERC state that 'protocols for specific emergency procedures (initiation of mechanical CPR, emergency pacing, pericardiocentesis, ventric ular assist devices) should be established. On-

familiarisation of the staff'.

Training in simulated catheter lab emergencies is provided at the annual meeting of the BCS (www.bcs.com) and there is a

Cardiac Advanced Resuscitation Education group (C.A.R.E.—www.csu-als.org).

We recommend that catheter laboratory specific training

cognitive aids to augment the quality of the specialist resusci

ILCOR also recommend debriefing stating that data-

	Class	Level
all staff working in this area, including training in the protocols contained in this document, and emergency drills for mechanical cardiopulmonary resuscitation (CPR), emergency pacing, pericardiocentesis and ventricular assist devices.	I	C
	IIb	C
	IIb	C

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practising interventional cardiac electrophysiologist. EG received Abbott Vascular educational funding. SR is a trustee of Heart Valve Voice and Immediate Past President of the British Cardiovascular Society. NO is Immediate Past President for the Association for Cardiothoracic Anaesthesia and Critical Care. CD is on the Executive Committee for the Resuscitation Council UKALS Working Group, ILCOR.

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Advanced Resuscitation Education (
ains clinicians worldwide for emergencies in catheter laboratories, emergencies after cardiac surgery, and thoracic emergency department care. JD is Deputy Editor
on the SCTS Thoracic Subcommittee, ISMICS Board of Directors 2017, and is STS Workforce Chairman for guideline for resuscitation after cardiac surgery. All other authors declare no competing interests.

Patient and public involvement atients were involved in the design, conduct, and reporting, with dissemination, and two patients are co-

Patient consent for publication

Ethics approval his study does not involve human participants.

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