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Society

Shock to Survival

A framework to improve the care and outcomes of people with cardiogenic shock in the UK

October 2022

Endorsed by the following professional organisations:

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Scottish Intensive Care Society
The College of Paramedics
The Northern Ireland Intensive Care Society

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Contents

Foreword

Every minute counts when it comes to managing patients presenting with cardiogenic shock (CS). Recognition, assessment and treatment of the condition is set against a background of different healthcare services and clinical pathways across all four nations of the UK. Critical decisions must be made quickly often with variable access to expertise in diagnosis and treatment. Not surprisingly, variation in clinical practice leads to inconsistent clinical outcomes, unpredictable healthcare costs and variable patient experience. This is a clinical landscape that urgently needs re-mapping.

'Shock to Survival' makes several recommendations based on a considered scoping of current practice. It suggests the ideal pathway for patients with CS bringing together best practice, the latest research, standards based on evidence, and consensus recommendations where gaps exist so that diagnostic delays are minimised and treatment is expedited.

Central to the recommendations is a model of care based on clinical networks and improvements in the processes for diagnosis, clinical classification and referral for specialist management. The authors recognise that every component of the system is vital. Access to specialist expertise through clinical networks should help to attain parity of access to high-quality care, while the continued training of all healthcare staff is essential in identifying patients with CS.

The authors explore how this newly re-mapped landscape will require re-design of current services and development of new services and how processes will require re-engineering for patients to reap the benefits. Credible leadership and collaborative working across professional boundaries will be essential.

Importantly the authors put the patient at the centre of all decisions about their care. In the dynamic environment of the acute care setting against the backdrop of potential life-threatening situations, the clear delivery of accurate information and the explanation of risks, benefits and alternatives becomes even more crucial. 'Shock to Survival' recommends that patients are included as part of all decision-making

"Critical decisions must be made quickly often with variable access to expertise in diagnosis and treatment"

processes and are fully informed of proposed interventions and are given the opportunity to agree to or to decline treatment. We must seek to “provide care that is respectful of, and responsive to, individual preferences, needs and values, and ensure that the patient’s values guide all clinical decisions”.

We recommend ‘Shock to Survival’ to all clinicians who care for patients with CS as well as policy makers and those who commission services across the UK. The recommendations set out a roadmap to enable improvements to be made which could ultimately transform the management and outcomes of patients with CS.

Mary Galbraith
Heart Patient

John Greenwood
President, British Cardiovascular Society

Stephen Webb
President, Intensive Care Society

“We recommend ‘Shock to Survival’ to all clinicians who care for patients with CS as well as policy makers and those who commission services across the UK”

Executive Summary

Patients with cardiogenic shock need defined pathways of escalation and care to improve survival

Cardiogenic shock (CS) occurs when a cardiac disorder means it can no longer supply adequate blood and oxygen to vital organs. This causes a life-threatening state known as hypoperfusion that can rapidly lead to multi-organ failure and death.

Nearly 1 in 10 myocardial infarction patients develop CS[2]. Currently, half of patients who develop CS will not survive to hospital discharge[3-5].

These high death rates are partly attributable to delays in recognition of CS and subsequent timely access to the evidence-based interventions and expertise required for optimal patient management.

Early identification of CS, rapid intervention to reverse the underlying cause, and immediate haemodynamic stabilization with or without the use of mechanical circulatory support (MCS) technologies are vital to improve survival. Observational data suggest that input and support from specialist multidisciplinary CS teams (CS-MDT) at an early stage in the patient pathway impacts survival. The CS-MDT provides 24/7 case-based discussion and treatment recommendations up to and including transfer to the CS Centre where indicated. Similarly, and in parallel with other acute illnesses such as stroke and myocardial infarction, cohorting of patients in regional, specialist CS Centres, is likely to improve patient outcomes. CS Centres acting as the hub of a regional network would provide the entire spectrum of cardiac diagnostics and therapeutics and access to invasive haemodynamic monitoring and MCS technologies required to manage this complex and dynamic condition. CS Centres also work closely with supra-regional Advanced Heart Failure Centres (AHFCs), where not co-located, to ensure all patients with CS who might benefit from advanced heart failure therapies including heart transplant are discussed.

“Cohorting of patients in regional, specialist CS Centres, is likely to improve patient outcomes”

The cardiology Getting it Right First Time (GIRFT) report emphasises the importance of networked models of care. Robust process, efficient pathways and effective training and education across networks are likely to be the first step towards improving clinical outcomes in CS.

In this document, we outline several recommendations as part of a systems approach to improving patient survival and experience. These include but are not limited to:

- Increase awareness among healthcare staff that any deteriorating patient with an elevated NEWS-2 score and evidence of hypoperfusion should prompt consideration of CS as a potential cause. Echocardiography (or focused cardiac ultrasound [FoCUS]) and electrocardiogram should follow urgently
- Improve access to echocardiography out-of-hours (including FoCUS with expert review), to support/exclude the diagnosis of CS or other cardiac pathologies
- Adopt SCAI staging as the standardised descriptor of CS to facilitate triage, communication and expediency of discussion with a CS Centre
- Establish CS Centres as part of regional CS networks to bring together the most critically ill patients with the right clinical expertise
- Ensure equity of access to CS expertise and care, including short-term MCS, through the design of CS networks and distribution of CS Centres
- Develop clear pathways of care and protocols for CS care within networks to complement existing acute cardiac care pathways, including 24/7 access to CS-MDTs and transfer to CS Centres
- Develop network protocols for patient selection for short-term MCS
- Define a minimum CS dataset, and collect this data, including through existing national audits, encompassing the entire patient pathway
- Prioritise high-quality research in CS to address important areas of uncertainty, including patient selection for short-term MCS and cost-effectiveness of improved care pathways.

The national Cardiac Pathway Improvement Programme (CPIP) represents an opportunity to embed many of these recommendations, to potentially transform outcomes in these patients, and CPIP leaders nationally and regionally should work with stakeholders and CS experts to implement them.

Introduction

Cardiogenic shock is a commonly encountered but often under-recognised clinical challenge with high mortality.

CS occurs when a problem with the heart means it can no longer supply adequate blood and oxygen to vital organs. This causes a life-threatening state known as hypoperfusion that can rapidly lead to multi-organ failure and death[1] (Figure 1). A myocardial infarction is the most common initiating event, but CS can also be caused by other problems such as inflammation of the heart muscle (myocarditis), side effects of drugs, as a complication of childbirth or deterioration of existing heart diseases including heart failure.

We do not know the true incidence of CS in UK hospitals. Data from Myocardial infarction Centres (HACs) suggests nearly 1 in 10 myocardial infarction patients may develop CS[2]. Currently, half of patients who develop CS will not survive to hospital discharge[3-5].

> **"Nearly 1 in 10 myocardial infarction patients may develop CS"**

In addition to uncertainty about the true incidence of CS, there is limited data to describe how care is delivered nationally for patients with CS. This is particularly true for an increasing majority of CS patients where a myocardial infarction is not the initial cause[6, 7]. In the absence of formal care pathways for patients with CS, we expect there to be significant variation in care across the UK and inequity of access to the highest quality care.

This document aims to describe the optimal pathway for people with CS. Our approach links existing pathways of acute cardiac and critical care and supports this with the available evidence base and national international guidance[1, 8, 9]. Where evidence or guidance does not exist, the UK Cardiogenic Shock Working Group (UKCSWG) has made consensus recommendations.

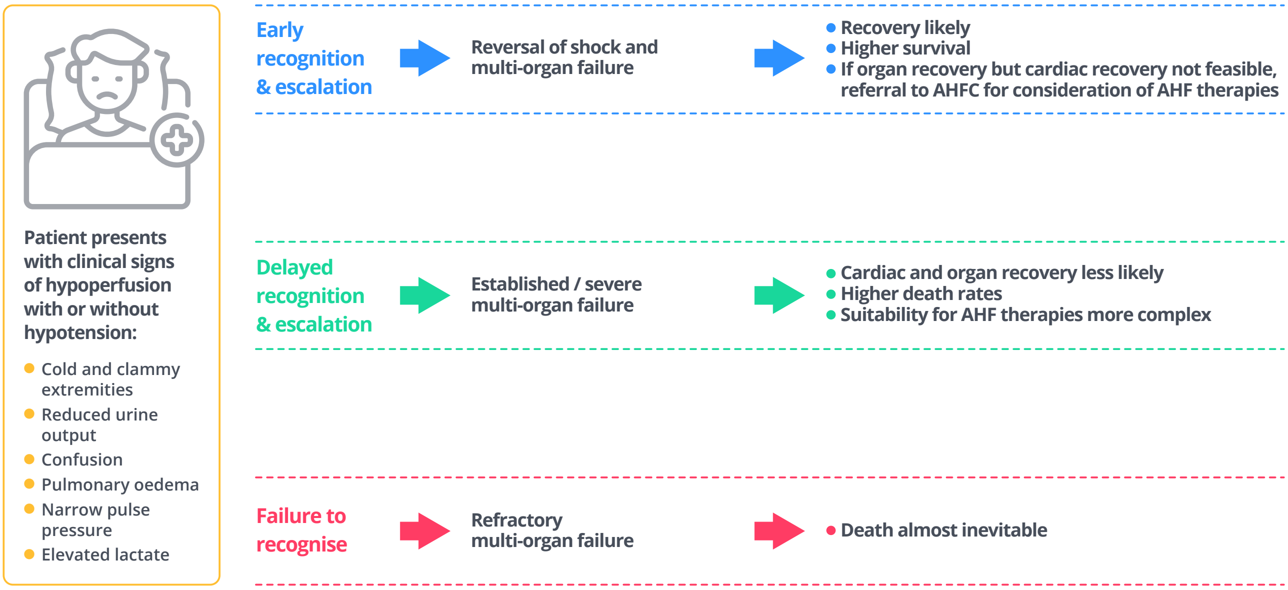

Figure 1. Patient outcomes for people presenting with CS and the importance of early recognition. AHF; Advanced Heart Failure, AHFC; Advanced Heart Failure Centre

Steps to survival

Early recognition of CS followed by rapid intervention to reverse the underlying cause and restore cardiac output is essential if more people are to survive.

CS is a complex illness that requires rapid recognition and care coordinated through regional centres that have the expertise, clinical experience and resources necessary to deliver a suite of emergency medical, surgical and mechanical therapies[9]. The persistently high death rate in CS is most likely attributable to delays in recognising its onset and obtaining timely access to the evidence-based interventions and expertise required for optimal patient management.

We see the key steps to increasing survival of CS patients as:

- Early recognition
- Early intervention to reverse cause
- Classify shock
- Early local escalation to buy time
- Early expert input from Network CS Centre

Achieving these steps will depend on adoption of early warning systems, ensuring timely access to diagnostic tools, and 24/7 access to multidisciplinary teams experienced in managing CS patients.

Early recognition of CS

CS diagnosis requires the presence of clinical and biochemical features that often vary and may overlap with other shock states.

The recognition of CS remains challenging. Diagnosis requires the presence of clinical signs of hypoperfusion, such as cold and clammy extremities, reduced urine output, mental confusion, dizziness and low (narrow) pulse pressure. Biochemical features include elevated serum creatinine, metabolic acidosis and elevated serum lactate, which indicates low tissue oxygen levels. Hypotension, defined as a sustained systolic blood pressure <90mmHg, has been used as a diagnostic criterion for CS in clinical trials[10, 11]. However, hypoperfusion not hypotension is the defining characteristic and patients with CS may present with hypoperfusion without hypotension[12].

This wide variety of clinical signs reflects the range of potential underlying causes, the co-existence of other overlapping shock states, including sepsis, and that CS is accompanied by cardiac arrest in around 1 in 6 cases[13, 14]. The National Institute for Health and Care Excellence (NICE) makes occasional mention of CS within its guidance[15-17] but there is no definition provided, nor recommendation on how to recognise CS[15-17].

"The cause of CS may not be the primary reason the patient has been admitted to hospital"

Importantly, the cause of CS may not be the primary reason the patient has been admitted to hospital or it may be recognised late with admission under an alternative diagnosis. Patients can therefore deteriorate during their care via multiple hospital teams, including emergency departments, medical wards, and obstetric units where expertise in acute cardiac care and diagnostics may be limited, particularly out of hours. Consideration of CS as the cause of deterioration or shock in any given patient is further challenged by the unknown prevalence of CS in UK hospitals and limited clinical awareness of CS and its presentations.

Early Warning Scores

CS should be considered in any deteriorating patient with an elevated NEWS-2 score and evidence of hypoperfusion.

Unlike sepsis[18], there is no validated tool to support in-hospital identification of CS. In UK hospitals, healthcare professionals use a combination of the National Early Warning Score (NEWS-2)[19] and their clinical judgment to determine whether a patient's health is deteriorating. NEWS-2 uses an aggregate scoring system, where points are allocated based on six physiological parameters[19] and scoring above a specific threshold triggers an urgent clinical response[20]. NEWS-2 is not yet validated for assessing CS, but it has been successfully embedded in clinical practice for diagnosing septic shock, which has many overlapping features with CS.

We suggest that CS should be considered as a diagnosis in any deteriorating patient with an elevated NEWS-2 score (≥5) and evidence of hypoperfusion. In patients with evidence of hypoperfusion, cardiac function should be immediately assessed using focus cardiac ultrasound (FoCUS) and electrocardiogram (ECG) performed to exclude acute coronary syndrome (ACS) or heart rhythm abnormality as the cause. FoCUS is a test used to identify cardiac dysfunction as the cause of shock and can also diagnose specific causes of CS such as valve abnormalities or cardiac tamponade (fluid build-up around the heart).

Patients at particular risk of CS, and where index of suspicion should be high, include those with an elevated NEWS-2 score and evidence of:

- existing or new cardiac pathology including heart rhythm abnormalities
- clinical signs of lung congestion or peripheral hypoperfusion, particularly cold, mottled extremities
- a shock state where the cause is unclear or does not respond to initial management such as fluid resuscitation or vasopressors
- increased lactate levels (venous or arterial)
- a narrow pulse pressure.

Locally agreed critical care escalation procedures should be actioned for patients who meet these criteria, but if a patient has evidence of hypoperfusion and organ dysfunction with elevation of blood lactate levels, FoCUS should be performed in all cases to exclude CS[1]. Once a diagnosis of CS is confirmed, teams should seek cardiology support, where available, to support management and further diagnostic tests.

Steps are needed to:

1. Increase the awareness of CS among acute care teams including critical care outreach, specifically in response to a high NEWS-2 score with evidence of hypoperfusion
2. Emphasise the high risk of death from CS and the importance of recognising it early and rapidly identifying and reversing the underlying cause to improve survival
3. Highlight hypoperfusion as the defining characteristic of CS with or without hypotension
4. Emphasise the use of FoCUS in patients with clinical evidence of hypoperfusion and/or refractory shock to support the early diagnosis of CS and guide initial management.

We see this framework as the first step in increasing awareness, which we hope will lead to other measures such as training and education in CS at an early stage and throughout medical and nursing training and increased availability of emergency diagnostics.

“We suggest that CS should be considered as a diagnosis in any deteriorating patient with an elevated NEWS-2 score”

Access to diagnostics

We need better access to emergency echocardiography if we are to prevent more people dying from CS.

International guidelines recommend that echocardiography should be performed when patients are admitted with suspected CS or acute heart failure[1, 9, 21]. The GIRFT report[22] and the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) Failure to Function[23] reports also emphasise the importance of timely access to diagnostic imaging.

Emergency echocardiography, including FoCUS, has limited availability compared to other life-saving diagnostic tests such as computed tomography (CT) scans. There is an urgent, unmet need to develop a cadre of accredited echocardiographers available 24/7 to support CS diagnosis and management. Providing a reliable and resilient 24/7 FoCUS service to support CS diagnosis is essential and will require collaboration between echocardiographers, cardiologists, intensive care, anaesthetics, acute medicine and emergency medicine teams. FoCUS should be complemented as soon as possible with advanced echocardiography for all patients to support detailed diagnostics and prognostication.

> **“Providing a reliable and resilient 24/7 FoCUS service to support CS diagnosis is essential”**

The UKCSWG recommends that societies work with NHS commissioners and health educators to increase provision of both FoCUS and accredited echocardiography assessment across a wider range of in-patient services. This will ensure both resilience and quality of image acquisition in CS. Further, the creation of regional CS networks and electronic image transfer systems across these networks will enable scans to be reviewed by accredited specialists at remote centres, enabling faster, accurate diagnosis.


Vivid iq

Right intervention, right patient, right time

Beyond recognition of CS, rapid identification and reversal of the underlying cause is essential to improve outcomes.

Early recognition is a crucial first step to improving CS patient outcomes, but this must be combined with rapid identification of the cause and intervention to reverse it, together with a standardized way of estimating and communicating individual patient risk. This requires access to the right data, the right specialists and the right interventions for the right patient at the right time.

Right Patient

Right Time

Right Data

Right Specialists

Right Intervention

The right data and the right intervention

Although a myocardial infarction is the most common cause of CS, it is not the only cause. Diagnostic workup should therefore exclude other causes such as acute valve regurgitation, pulmonary embolism, infection, acute myocarditis, arrhythmia, fluid build-up around the heart (cardiac tamponade) combined with immediate interventions to stabilise and restore blood flow to vital organs.

The only treatment that has demonstrated efficacy in CS is emergency revascularisation after a myocardial infarction (i.e. through percutaneous coronary intervention or bypass surgery)[11]. It is therefore essential that all patients with acute coronary syndrome and CS should have access to emergency coronary revascularisation through the national Heart Attack Centre (HAC) pathway. Similarly, where disease-specific interventions exist (e.g. interventions for pulmonary embolism or management of structural heart disease or heart rhythm disorders), it is essential patients are offered these potentially life-saving interventions through existing NHS pathways.

The right patient: importance of early triage

Accurate triage of patients with CS will enable rapid communication of their health status and optimize their care.

In parallel with assessment for reversible causes, immediate haemodynamic stabilisation and restoration of cardiac output, the additional phase of patient management is to triage the patient according to Society for Cardiovascular Angiography and Intervention (SCAI) criteria and determine:

- if transfer to a specialist centre for cardiac intensive care, advanced haemodynamic monitoring and imaging, and consideration of MCS is indicated
- where care would be optimally delivered both if the patient is being transferred and if they remain at the referring hospital
- the time-sensitivity of transfer
- how the patient will be safely transferred.

SCAI has proposed a classification schema for CS, which characterizes the spectrum of CS from “at risk” to “extremis”[24].

The staging system (Figure 2) has been shown to reliably predict a patient’s risk of death[25-27] and has been increasingly adopted into clinical care in many healthcare systems[13].

In addition to the descriptors shown in Figure 2, it also identifies other factors including age, long-term conditions (comorbidities), frailty and cardiac arrest with coma which may further influence a patient’s outcome[13].

Although the SCAI descriptors have not been validated in the recognition of CS, they provide a standard framework for rapidly communicating a patient’s health trajectory between teams, which can be used to determine the time sensitivity and/or appropriateness of emergency interventions such as mechanical circulatory support (MCS).

> **“The staging system has been shown to reliably predict a patient’s risk of death”**

We recommend that SCAI staging becomes the standardised descriptor of CS to facilitate triage and expediency of discussion with a CS Centre (see Page 28).

Patients in SCAI stage B or above, or those with any escalation in SCAI stage despite optimal medical management, should be referred to a CS Centre. SCAI staging, combined with clinical assessment of restored organ perfusion and clearance of serum lactate, should be re-evaluated serially to assess for response to treatment.

We recommend implementing a minimum dataset to support referral to CS Centres that incorporates clinical, biochemical and haemodynamic data (including FoCUS) and is standardised at a regional, national or UK-wide level to ensure consistency of practice.

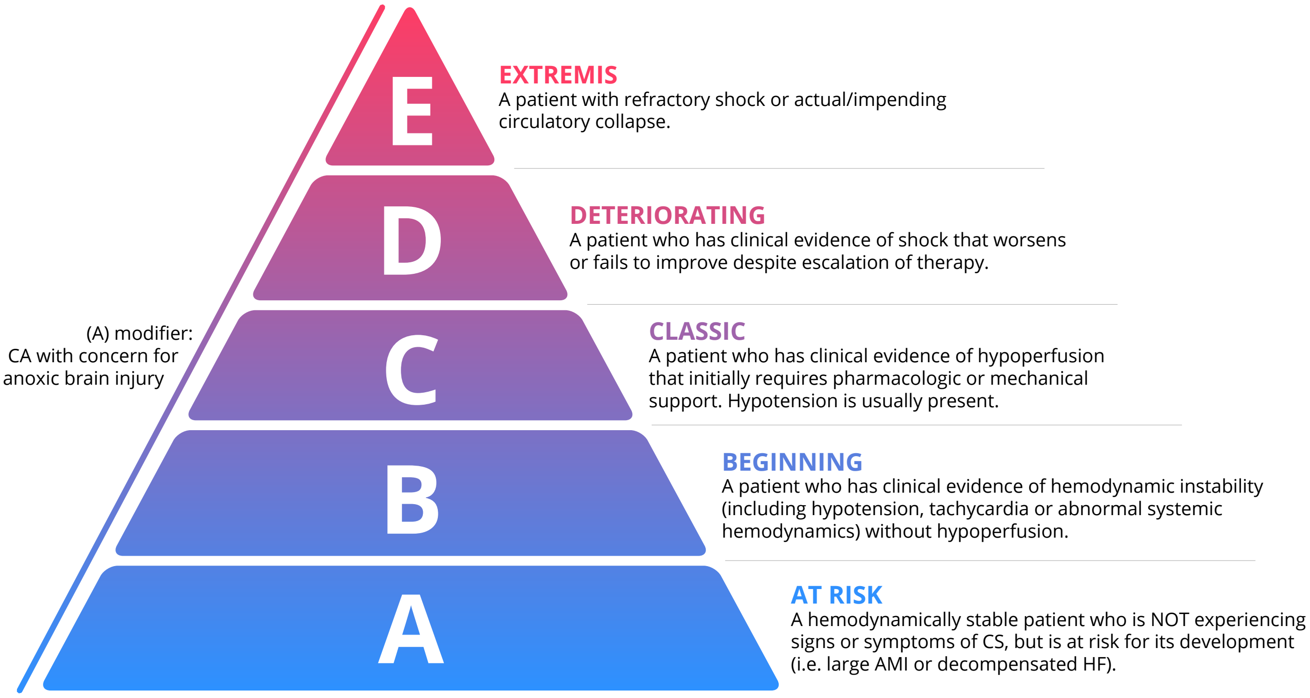

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Figure 2. SCAI SHOCK classification pyramid. AMI, acute myocardial infarction, CA, cardiac arrest, CS, cardiogenic shock, HF, heart failure, SCAI, Society for Cardiovascular Angiography and Interventions.

The role of mechanical circulatory support (MCS)

MCS use should be guided by the CS-MDT and is an essential support modality in CS in select patients

Despite early recognition, treatment of the underlying cause and appropriate measures to stabilise and restore cardiac output, some patients may deteriorate or remain refractory despite conventional medical therapies (SCAI stages C to E). In addition, some patients may be identified late in their CS trajectory and some may present to hospital in the most severe stages of the CS spectrum. In these patients, MCS may the only intervention to prevent progression to multi-organ failure, cardiac arrest and inevitable death. The working group acknowledge that randomised trial data to support large scale use of MCS in CS of all aetiologies and stages CS is lacking. Nonetheless, observational data suggest that more than acceptable survival rates can be achieved when MCS is used in carefully selected patients before the onset of multi-organ failure[28, 29].

The true demand for MCS is unknown; there are no registries of CS in the UK that accurately describe MCS use or patient outcomes. We do know that a significant volume of non-commissioned MCS is being undertaken nationally in patients with CS.

> **“There are no registries of CS in the UK that accurately describe MCS use or patient outcomes”**

In line with societal guidance[1], provision of short-term MCS is an essential requirement for CS services, in select patients, as a bridge to decision, bridge to recovery, bridge to candidacy for either long-term MCS or urgent heart transplantation. MCS should complement conventional medical care. There should be improved equity of access to MCS for those patients deemed most likely to benefit. Where an uplift in MCS capability is required to ensure equity of access, training and education should be supported by those networks with established MCS expertise. In the absence of national guidance, patient selection for MCS and timing of MCS use should be guided by CS-MDT discussion and network escalation protocols. These should be informed by societal guidance[1, 30] and iterated as clinical trial data emerge. Pathways towards regulating and funding this activity are outlined in page 35.

The right specialists: CS-MDTs

CS-MDTs will bring multidisciplinary expertise in CS immediately to the patient's bedside, wherever they are admitted.

The concept of multidisciplinary team (MDT) care is well established in elective cardiac care[31, 32]. Recognizing CS as a highly complex condition, requiring intensive monitoring (high-acuity care) and time-sensitive intervention, cardiogenic shock MDTs (CS-MDTs) have evolved to expedite multidisciplinary discussion regarding optimal patient management in the emergency setting[29, 33].

CS-MDTs are based at networked CS Centres (see pages 25-28) and typically comprise an interventional cardiologist, a cardiac intensivist, cardiac critical care nursing staff, a heart failure cardiologist and a cardiac surgeon with or without a member of the regional transplant team or specialist palliative care.

The CS-MDT is not simply a gathering of multi-professional clinicians but a dynamic collective working towards a shared goal of optimising individual patient management, using their cumulative experience and expertise[33]. It should be capable of providing rapid support and advice (within minutes of referral) 24 hours a day, 365 days a year, using the following escalation process:

> **"It should be capable of providing rapid support and advice (within minutes of referral) 24 hours a day, 365 days a year"**

1

Referring physicians would access the CS-MDT via a dedicated phone number or online referral pathway to a 24/7 duty CS clinician or coordinator (nursing or physician) at the regional CS Centre.

2

The duty CS clinician or coordinator will manage the referral and establish an emergency meeting between the referrer and the CS-MDT using conferencing platforms, now well established following the Covid-19 pandemic.

3

The duty CS clinician or coordinator will manage ongoing input from the CS-MDT, including coordination of patient transfer to the CS Centre or patient retrieval by a mobile CS team (see page 33) as well as provide ongoing follow-up and clinical support for patients not transferred to the regional CS Centre.

Given the dynamic nature of CS, referral to or input from a CS-MDT may not be a single event and ongoing input might be required for patients not immediately transferred to a CS Centre. The CS coordinator should play a key role in the follow-up of these patients. Where feasible, it is essential that patients or their families are informed and updated about their proposed treatment, including transfer to a CS Centre, to ensure shared decision-making throughout the patient journey.

Involving CS experts early in care planning of patients with CS has resulted in more efficient use of invasive haemodynamic monitoring and MCS technologies and has improved survival from CS from approximately 50% to 70-75% in observational studies[34, 35]. We recommend the development of CS-MDTs within regional CS Centres as a high impact intervention to bring MDT expertise in CS immediately to the patient's bedside, wherever they are admitted.

The CS-MDT is crucial for:

- providing clinical support to referrers, including interpretation of echocardiography, ECG and haemodynamics
- facilitating interventions tailored to the specific cause of CS, particularly where these are not available locally
- efficiently triaging patients to an appropriate care location; either transferring to the CS Centre or to receive MDT advice on optimal management in the local critical care environment
- identifying patients who are unlikely to benefit from advanced cardiac care because they are too ill, have a poor prognosis or to avoid unnecessary transfer and potential geographical dislocation from their family and friends
- supporting safe and timely transfer of select patients to the CS Centre
- identifying patients who may need emergency MCS at presentation (where available) or mobile MCS during transfer to the CS Centre
- supporting the management of patients once transferred to the CS Centre.

Case study: A CS network in action

Mrs J is 43 years old and living with familial dilated cardiomyopathy. Three years ago she supported her sister through heart transplantation. She understood she may also need a transplant at some point, but was comforted that her condition remained stable for years. Then, she started feeling more breathless. Her cardiologist increased her medications and she felt better, but she knew her heart failure was catching up with her.

Early recognition

Mrs J's symptoms continued to deteriorate. Her husband eventually brought her into the local hospital when she became so breathless she could not walk to the bathroom. Her legs were swollen and she had fluid in her lungs. Once admitted to hospital, Mrs J received intravenous furosemide and her symptoms started to improve. However, five days into her treatment, she noticed her breathing was becoming more laboured. Her kidney and liver function tests also started to deteriorate. Her consultant cardiologist, who had previously worked in an AHFC during training, recognised Mrs J's gradual deterioration into CS and commenced inotropic support to stabilise her circulation and optimise oxygen delivery to her organs. Mrs J was rapidly referred to the AHFC for consideration for MCS and a heart transplant.

Multidisciplinary care

Mrs J was transferred to the AHFC the next day. By this stage, it was clear that Mrs J was declining with liver and kidney injury and a rise in blood lactate level. An echocardiogram showed severe impairment of left and right heart function. A right heart catheter study confirmed very low cardiac output.

A team comprising a cardiologist, cardiac surgeon and cardiac intensivist, the CS-MDT, was convened urgently to review Mrs J and plan her ongoing care. The decision was unanimous, including the patient's wishes, and the plan was implemented without delay. Mrs J had surgery to implant a temporary biventricular assist device, an external heart pump that would take over the function of both right and left side of the heart. Two days later, as her liver and kidney function tests returned to normal, she was placed on the waiting list for a heart transplant. A team of physiotherapists, dieticians and clinical psychologists worked with Mrs J during this period to maintain conditioning for her transplant. Mrs J underwent an uncomplicated heart transplant two weeks later and was discharged at 22 days.

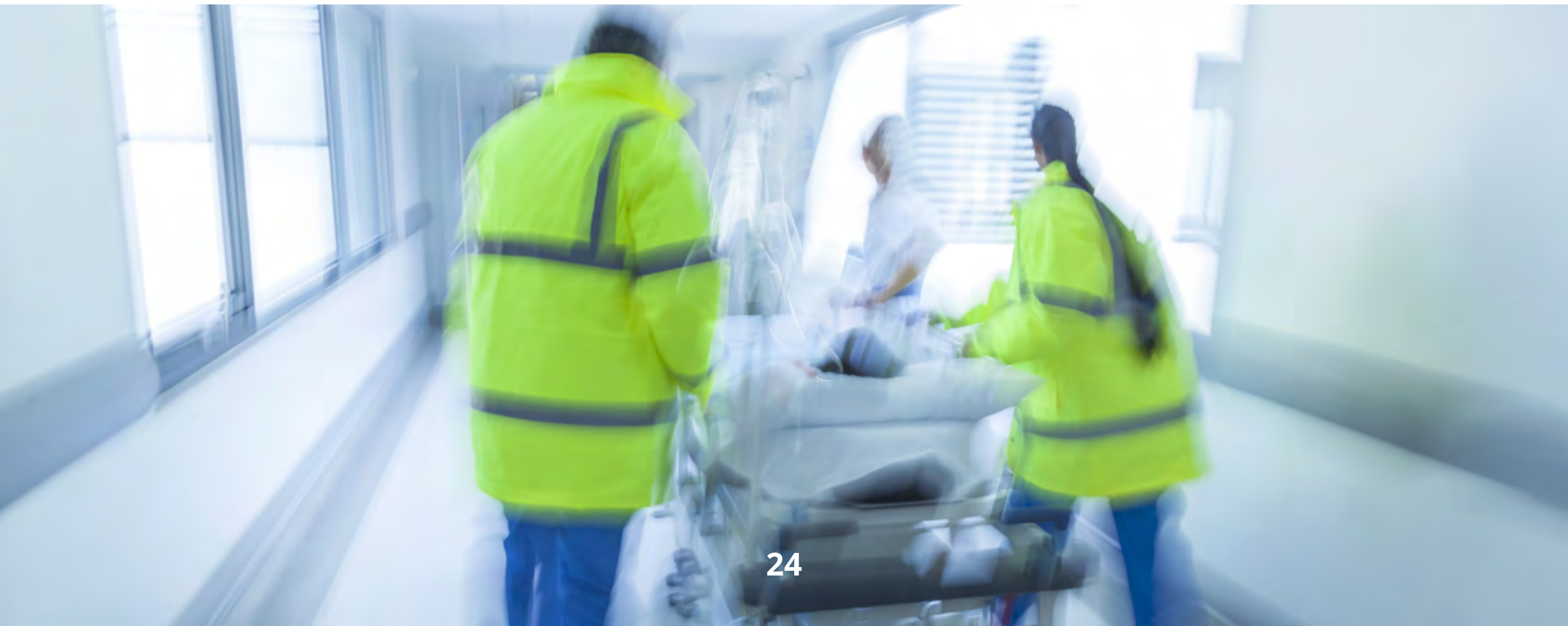
A successful outcome

The successful outcome in this case was shaped by a series of events, all of which led to early intervention before Mrs J spiralled into irretrievable multi-organ failure and likely death.

First, the evolving CS was recognised by the cardiologist at the local hospital. His training and experience in advanced heart failure was crucial in the management of CS.

Second, a bed at the AHFC was available to accept the referral within 24 hours. With significant and competing demands on hospital beds, a delay in transfer of several days is common and is frequently the seminal event that defines clinical success and failure in CS.

Third, the decisions and interventions by the team at the AHFC were instrumental. The acute MCS, stabilisation of the patient and subsequent heart transplant can only be achieved through effective team-delivered care. Effective multi-disciplinary team care is central to a successful CS service, but is arguably one of the most difficult elements to deliver consistently.



Network models of CS care

Network models of care will lead to better CS outcomes through robust processes, efficient pathways, effective training and shared learning.

The case for CS networks is strong, based on evidence of reduced mortality achieved by network care models for other complex, time-sensitive emergencies, such as the regionalised Trauma Centres[36], Heart Attack Centres[37] and Severe Acute Respiratory Failure Centres[38]. Some of the more compelling observational data in CS point to both a mortality benefit and more judicious MCS use through a network approach to CS care, whereby CS-MDTs and locally agreed escalation algorithms inform patient escalation and transfer[28, 29, 34, 39].

The cardiology GIRFT report emphasizes the importance of a network model; one that focuses on improving clinical pathways and, of particular importance in CS patients, ensures equitable care and access to the best care[22]. Networks for CS care are also recommended in societal guidance[1, 8, 9] and should be developed and appropriately resourced as a priority in the UK.

The network concept is based on the idea that hospitals within any network understand both their capabilities and limitations to manage any given patient with CS across a range of severities. Robust process, efficient pathways and effective training, education and shared learning across networks are likely to be the first step towards improving clinical outcomes in CS.

“The cardiology GIRFT report emphasizes the importance of a network model; one that focuses on improving clinical pathways and, of particular importance in CS patients, ensures equitable care and access to the best care”

Building a CS network

The geographical distribution of CS networks should be designed with equity of access as the central tenet.

There is currently a lack of epidemiological data to inform CS network design. However, existing networks of HACs and the supra-regional Advanced Heart Failure Centres (AHFCs) provide a foundation. We therefore propose a network based on organisation and capacity building within existing infrastructure as opposed to re-organisation (Figure 3).

Importantly, there should be clearly established triggers for referral to the CS-MDT and CS Centre to avoid delays in escalation and transfer which may impact on outcome. Similarly, once patients no longer need specialist cardiac care, they should be repatriated to their referring hospital to maintain capacity and activity in CS Centres as well as supporting convalescence and follow-up in their local hospital (Figure 3).

Given the resource utilisation of CS patients and their impact on both elective and emergency activity, networks should work in collaboration to ensure resilience in capacity, equipment and staffing in CS Centres and AHFCs alike.

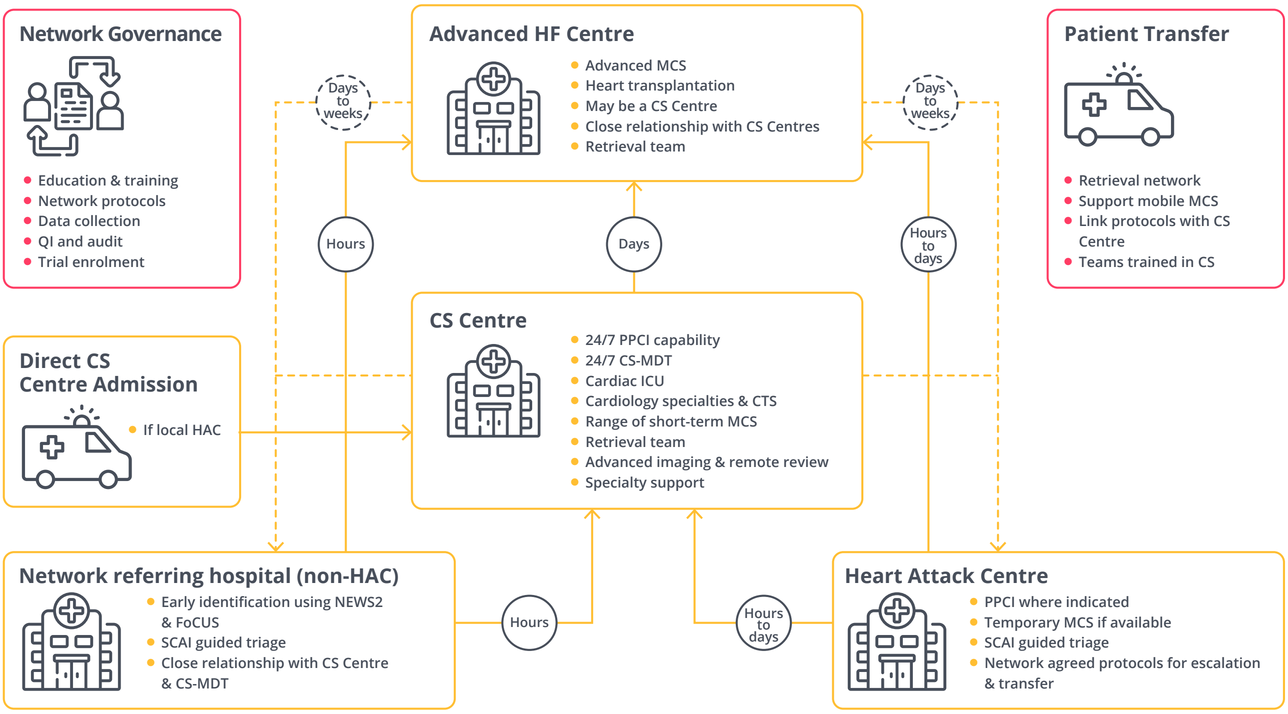


Figure 3. Structure and governance of a CS network. Patients are transferred either to a CS Centre or to an Advanced Heart Failure Centre depending on the cause of their CS with a suggested timeline of both referral and repatriation. Where the local HAC is also a CS Center, patients may be transferred directly by ambulance services for PPCI. CS: Cardiogenic Shock, CTS: cardiothoracic surgery, FoCUS: Focussed Cardiac Ultrasound, ICU: Intensive Care Unit, HAC: Heart Attack Centre, HF: heart failure, MCS: mechanical circulatory support, MDT: multidisciplinary team, NEWS2: National Early Warning Score, PPCI: primary percutaneous coronary intervention, QI: quality improvement, SCAI: Society for Cardiovascular Angiography and Interventions.

CS Centres: leading and supporting a network

Centres with specialists and the highest volume of CS care are likely to have better patient outcomes.

At the heart of the proposed CS network are designated CS Centres, which provide a critical mass of specialist medical, nursing and allied health professional expertise.

Hospitals that carry out high numbers of cardiovascular procedures have been consistently and positively associated with improved clinical outcomes including increased patient survival[40-42]. The same is true in CS: increased hospital volume of CS care is associated with improved outcomes[43, 44].

The complex medical, catheter-based, and surgical treatments necessary to care for patients with the severest stages of CS, coupled with advanced haemodynamic monitoring and support technologies, requires specialist expertise. It follows that grouping both patients and clinical expertise together in designated CS Centres is desirable and should be established.

The service specifications of a CS Centre should support its role as the central hub of a regional network of care. It should:

- design and deliver a robust and resilient referral pathway for patients with CS
- provide 24/7 access to a CS-MDT with clear lines of communication to support patient discussion and treatment recommendations including transfer to the regional CS Centre
- create robust arrangements for rapid transfer to the CS Centre in select patients
- ensure equity of access for patients and referrers to the CS-MDT and minimise unwanted variation in care across a regional network
- develop and implement evidence-based protocols for referrals to the CS-MDT team, transfer to CS Centres, escalation of care to MCS or positive decisions to pursue end-of-life care

> **“At the heart of the proposed CS network are designated CS Centres”**

- provide leadership and coordination to the network through a dedicated CS network lead with protected time
- have capability for both univentricular and biventricular short-term MCS devices as a bridge to decision, bridge to advanced heart failure treatment and as a bridge to long-term MCS to assess transplant candidacy
- work closely with supra-regional AHFCs, where not co-located, to ensure all patients with CS who might benefit from a heart transplant are discussed
- support education and training in the awareness, recognition and management of CS and embed escalation protocols across the network
- have a governance structure to support audit, quality improvement and bi-directional learning across the network
- contribute to national audits and registries to generate outcome data for patients with CS and support patient enrolment in clinical trials.

We view pathways for CS patients as complementary to existing acute cardiac care pathways, which already support the needs of the most critically ill patients and will ensure timely access to evidence-based therapies. We anticipate that lines of communication for CS should not interfere with established acute cardiovascular care pathways but should support them in those patients with haemodynamic instability.

As highlighted by Mrs J's case study, it may be appropriate to transfer patients who are unlikely to recover and are eligible or already listed for a heart transplant, directly to the supra-regional AHFC in the first instance (Figure 3).

"We view pathways for CS patients as complementary to existing acute cardiac care pathways, which already support the needs of the most critically ill patients"

CS Centres: a team of teams

Once CS is recognised, a team of teams is required to provide the entire spectrum of cardiology services, heart surgery and appropriately resourced cardiac intensive care.

It is essential that CS Centres have the capability to diagnose and manage the entire spectrum of heart disease including cardiac arrest. This requires 24/7 access to expertise in catheter-based treatments (interventional and structural cardiology), heart rhythm studies (electrophysiology), heart failure, imaging and heart surgery. Cardiology input throughout the patient pathway is essential to ensure access to guideline-based interventions and pharmacotherapy, cardiac diagnostics and appropriate follow-up on hospital discharge.

> **“As myocardial infarction is the largest single cause of CS, access to 24/7 coronary revascularisation (PPCI or surgical) should be a minimum specification for a CS Centre”**

As myocardial infarction is the largest single cause of CS, access to 24/7 coronary revascularisation (PPCI or surgical) should be a minimum specification for a CS Centre. The availability of this expertise and access to catheterisation laboratories will also support the provision of short-term MCS in CS Centres. Centres with existing expertise in both CS and MCS, including the AHFCs, should support the development of a wider network of CS Centres to ensure UK-wide equity of access.

The capability to provide MCS for the most critically ill CS patients should be a service specification for CS Centres. In addition, there is a role for MCS, outside of CS Centres, to support the deteriorating patient with an acute coronary syndrome receiving PPCI[1, 8, 9]. A number of HACs across the UK have established an MCS programme to provide percutaneous microaxial pumps and veno-arterial extracorporal membrane oxygenation (VA ECMO) in the catheter laboratory to support the deteriorating or high-risk patient. Although few of these centres will be required to function as a designated CS Centre, their capabilities should be harnessed within a CS network (Figure 3). Patient selection for MCS in such centres should be guided by network protocols, supported by the CS-MDT and governed in-line with network agreed policies. All aspects of CS care, but especially decisions around MCS, should be respectful of and responsive to individual patient preferences, needs and values.

The causes of CS are varied and the associated complications of CS may be multisystem. CS patients therefore need access to wider specialist services including but not limited to vascular surgery, interventional radiology, neurology and obstetrics. In patients who do survive, their stay in critical care can be prolonged and allied health specialty input is crucial to recovery. The poor survival rates for CS calls for specialist palliative care services to support both patients and their families. For those who survive, the burden of heart failure is significant requiring access to heart failure services, specifically heart failure nurse specialists and cardiac rehabilitation. Psychiatric disease and psychological distress is common. In essence, a team of teams is required across the patient pathway to improve outcomes and ensure best care.

The role of Advanced Heart Failure Centres

Patients with CS who do not respond to treatment and optimal cardiac support may benefit from a heart transplant at an AHFC, with MCS as a bridge to transplant or transplant candidacy.

Heart transplant is an excellent treatment for selected patients with advanced heart failure, with most patients returning to a normal quality of life and half of them living for a further 12.5 years[44].

Patients with difficult to treat CS and who are highly likely to die with conservative treatment may gain life-years if they receive a heart transplant. However, such patients must be very carefully selected because serious long-term conditions such as severe lung disease or irreversible end-organ damage are associated with poor outcomes.

Six AHFCs are commissioned to provide heart transplants to adult UK residents and eligible overseas patients[45]. Most patients are referred to the closest AHFC, although English centres have no fixed catchment areas.

One of the challenges is that capacity at AHFCs is limited and a centre will only accept a patient if a critical care bed is available. If an eligible patient cannot be immediately transferred to an AHFC, then local CS Centres may be able to provide temporary MCS as a stabilising measure.

MCS is commissioned as a bridge to a heart transplant or heart transplant candidacy (to reverse specific contra-indications). The number of patients treated with temporary MCS as a bridge to heart transplantation has increased five-fold over the last ten years[46]. In 2019/2020, 114 patients were supported with VA ECMO or a temporary left ventricular assist device (LVAD) in the six UK AHFCs[46].

> **"Patients with difficult to treat CS and who are highly likely to die with conservative treatment may gain life-years if they receive a heart transplant"**

Transferring patients across CS networks

Many patients will be identified outside specialist CS Centres and teams must be resourced to facilitate timely transfer of those patients who need specialist care.

The retrieval of patients with CS from local hospitals to specialist centres is not currently commissioned. However, transfer of unstable critically unwell patients across networks facilitated by regional critical care transport services is now routine. Transfer of patients receiving MCS is feasible, but requires highly specialised medical, perfusion and nursing expertise[46].

Given the dynamic nature of CS, there is potential for patients to deteriorate during inter-hospital transfers. We recommend that SCAI staging combined with clinical assessment is used to triage both the urgency of transfer, the risk of deterioration during transfer and the requirement for specialist critical care transfer teams (where available). The decision to transfer the most unwell patients with CS should balance the risk posed to the patient of the transfer, with the benefits of receiving specialist care. All patients should be informed of the recommendation to transfer, where feasible, and should inform this decision in line with their own values.

In some cases, mobile MCS will need to be provided to patients before their transfer to a CS Centre. In sectors where critical care transfer services are established, the Association of Anaesthetist guidelines on inter-hospital transfer should be followed[47] and specific training in the management of CS retrievals should be established.

Receiving CS Centres must also be adequately resourced to facilitate timely transfer of patients with CS. When capacity is limited, CS Centres within a network or across networks should collaborate to create capacity and ensure resilience. This model is well established within the national Severe Acute Respiratory Failure Network[38].

> **“Transfer of patients receiving MCS is feasible, but requires highly specialised medical, perfusion and nursing expertise”**

Moving from ad-hoc services to formative pathways

The NHS is well-placed to deliver high-quality CS care and better patient outcomes.

A key strength of the NHS is its ability to implement UK-wide change. We acknowledge the NHS has important cost constraints, but the key foundation for improved CS care is through process improvement and network-based care. On that basis the NHS is well placed to deliver high-quality CS care and better patient outcomes.

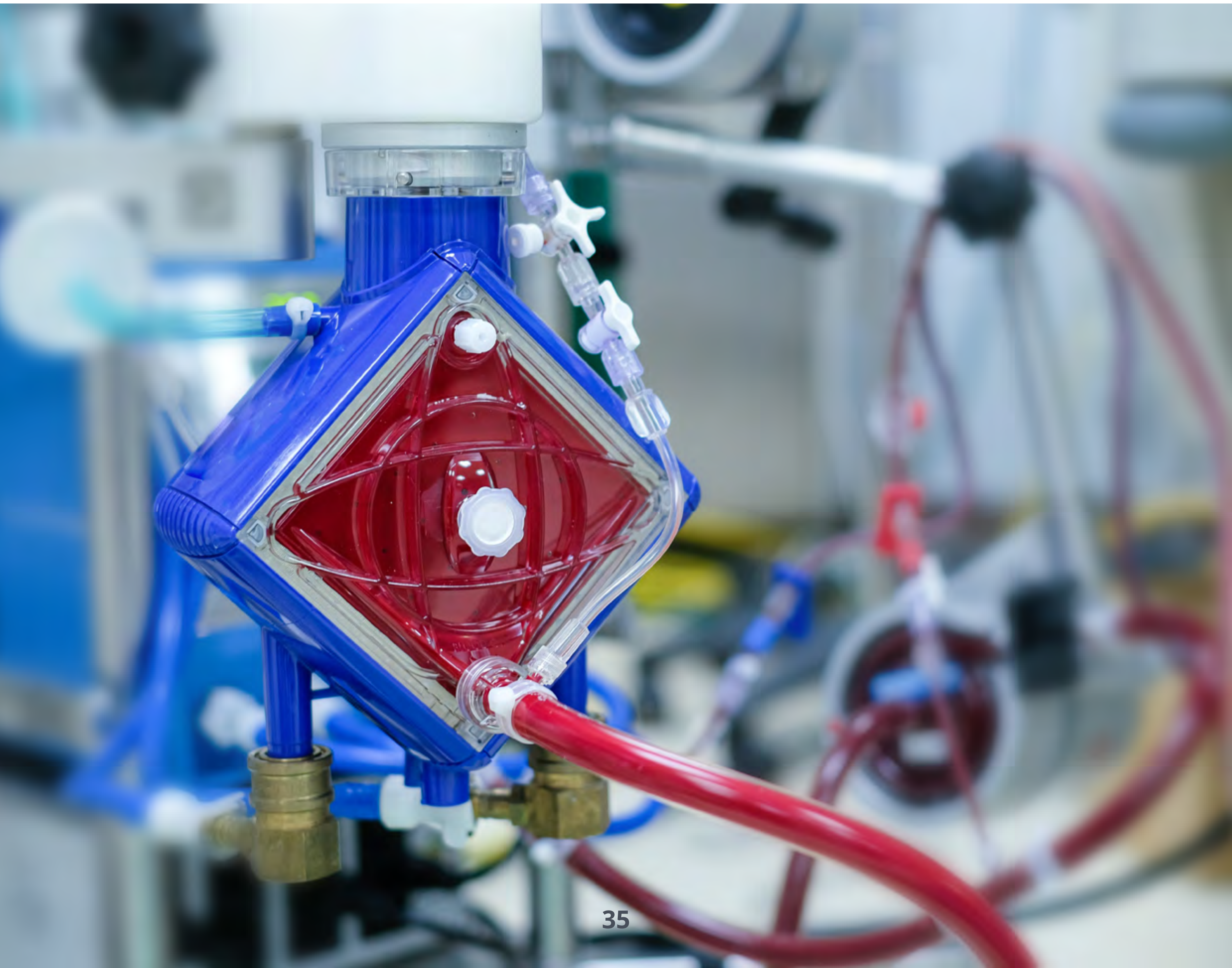
Embedding the development of CS networks into existing NHS structure and pathways will require leadership, coordination and resource but crucially will improve equity of access, efficiency and - we strongly believe - patient outcomes and experience.

Operational Delivery Networks are optimally placed to work closely with Strategic Clinical Networks, commissioners, providers and patients to delineate and design networks and explore integration into existing pathways of care and funding streams.

“The national Cardiac Pathway Improvement Programme (CPIP) represents a unique opportunity to improve outcomes and patient experience, and reduce inequity of access”

The national Cardiac Pathway Improvement Programme (CPIP) represents a unique opportunity to improve outcomes and patient experience, and reduce inequity of access. The UKCSWG strongly recommend that CPIP leaders nationally and regionally work with stakeholders and CS experts to outline best practice pathways for CS incorporating the recommendations outlined within this document.

MCS has previously failed to be commissioned nationally because of a lack of high-quality randomised controlled trial evidence and resource constraints. Nonetheless, it is an essential support modality in CS. MCS will therefore continue to be used nationally at significant cost. We recommend that specialist commissioning groups explore options for reimbursement of MCS. Reimbursement should be linked to patient data submission to better understand patient selection, patient outcomes and wider resource use; these data are currently unavailable. Whilst we await the results of MCS clinical trials, clinicians should engage with both industry and commissioners to identify mechanisms to generate the requisite level of evidence to support commissioned funding for short-term MCS technologies outside of bridge-to-transplant pathways.



Data to drive change

High-quality data are fundamental for designing services and improving patient outcomes. These data impact decisions at the patient-level, at organisational and service delivery level, and through national and UK-wide guidelines and policies.

Several existing databases and national audits currently embedded in UK healthcare represent excellent practice in data collection and present opportunities to capture high-quality longitudinal data in CS. These include the Intensive Care National Audit and Research Centre (ICNARC) Case Mix Programme Database and the National Cardiac Audit Programme run by the National Institute for Cardiovascular Outcomes Research (NICOR).

The SWEDEHEART database provides the best comparator for the UK[48, 49]. SWEDEHEART's greatest strength is the assimilation of data from Sweden's National Patient Registry which contains hospital discharge diagnoses, the National Registry of Drug Prescriptions and the National Cause of Death Register. Data for the LAUNCHES QI project[50] and British Heart Foundation Data Science Centre[51] have demonstrated the potential for and opportunity of linked datasets to drive service design and understand cardiovascular outcomes across the patient pathway.

> **"Several existing databases and national audits currently embedded in UK healthcare represent excellent practice in data collection"**

The three themes key to successful data collection in CS

1. Encompassing the entire patient journey from admission to discharge and ideally long-term follow up including patient reported outcome measures
2. Ensuring data is obtained from a representative sample of patients including those not admitted with acute coronary syndromes to capture the varied causes of CS
3. Enriching data using data linkage to cover all patient episodes relating to CS

Key features of a CS database would include:

- A minimum dataset harmonized across all four devolved nations that aligns with established international registries and captures all patients with CS, whether transferred to a CS Centre or not
- A structure built upon existing audits and registries that are culturally embedded
- Linkage to national datasets or the ability to collect data at source
- Compliance with data protection regulations to allow collection of data for research and audit without patient consent
- Capture of quality and process of care data including SCAI staging to drive service improvement, patient safety and facilitate benchmarking
- Opportunity to perform health economic analysis
- Capability to derive risk prediction models to inform prognosis or to guide therapy.

Research to improve outcomes

There is a lack of high-quality evidence in CS to inform clinical practice and improve outcomes.

Although the UK continues to lead in many aspects of clinical and translational cardiovascular research, activity in CS is comparatively sparse. Cohorts of patients coming through CS Centres, combined with more consistent care across CS networks and linked national data collection, represent an opportunity for basic scientists, data scientists and trialists to improve patient outcomes.

To support this, each network should appoint a research lead to develop research infrastructure and output locally and collaborate nationally and internationally in emerging clinical trials. Research funding bodies should prioritise high-quality research in CS to help address important questions and on-going unmet needs. One immediate research objective would be to evaluate the use of NEWS-2 as a valid early warning system for CS.

> **“Cohorts of patients coming through CS Centres, combined with more consistent care across CS networks and linked national data collection, represent an opportunity for basic scientists, data scientists and trialists to improve patient outcomes”**

References

1. McDonagh TA, Metra M, Adamo M, et al. **2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure** [published correction appears in Eur Heart J. 2021 Oct 14;:]. *Eur Heart J.* 2021;42(36):3599-3726. doi:10.1093/eurheartj/ehab368
2. Rathod KS, Koganti S, Iqbal MB, et al. **Contemporary trends in cardiogenic shock: Incidence, intra-aortic balloon pump utilisation and outcomes from the London Heart Attack Group.** *Eur Heart J Acute Cardiovasc Care.* 2018;7(1):16-27. doi:10.1177/2048872617741735
3. Thiele H, Ohman EM, de Waha-Thiele S, Zeymer U, Desch S. **Management of cardiogenic shock complicating myocardial infarction: an update 2019.** *Eur Heart J.* 2019;40(32):2671-2683. doi:10.1093/eurheartj/ehz363
4. Thiele H, Akin I, Sandri M, et al. **One-Year Outcomes after PCI Strategies in Cardiogenic Shock.** *N Engl J Med.* 2018;379(18):1699-1710. doi:10.1056/NEJMoa1808788
5. Thiele H, Akin I, Sandri M, et al. **PCI Strategies in Patients with Acute Myocardial Infarction and Cardiogenic Shock.** *N Engl J Med.* 2017;377(25):2419-2432. doi:10.1056/NEJMoa1710261
6. Bohula EA, Katz JN, van Diepen S, et al. **Demographics, Care Patterns, and Outcomes of Patients Admitted to Cardiac Intensive Care Units: The Critical Care Cardiology Trials Network Prospective North American Multicenter Registry of Cardiac Critical Illness.** *JAMA Cardiol.* 2019;4(9):928-935. doi:10.1001/jamacardio.2019.2467
7. Berg DD, Bohula EA, van Diepen S, et al. **Epidemiology of Shock in Contemporary Cardiac Intensive Care Units.** *Circ Cardiovasc Qual Outcomes.* 2019;12(3):e005618. doi:10.1161/CIRCOUTCOMES.119.005618
8. Zeymer U, Bueno H, Granger CB, et al. **Acute Cardiovascular Care Association position statement for the diagnosis and treatment of patients with acute myocardial infarction complicated by cardiogenic shock: A document of the Acute Cardiovascular Care Association of the European Society of Cardiology.** *Eur Heart J Acute Cardiovasc Care.* 2020;9(2):183-197. doi:10.1177/2048872619894254
9. van Diepen S, Katz JN, Albert NM, et al. **Contemporary Management of Cardiogenic Shock: A Scientific Statement From the American Heart Association.** *Circulation.* 2017;136(16):e232-e268. doi:10.1161/CIR.0000000000000525
10. Thiele H, Zeymer U, Neumann FJ, et al. **Intraaortic balloon support for myocardial infarction with cardiogenic shock.** *N Engl J Med.* 2012;367(14):1287-1296. doi:10.1056/NEJMoa1208410
11. Hochman JS, Sleeper LA, Webb JG, et al. **Early revascularization in acute myocardial infarction complicated by cardiogenic shock. SHOCK Investigators. Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock.** *N Engl J Med.* 1999;341(9):625-634. doi:10.1056/NEJM199908263410901
12. Menon V, Slater JN, White HD, Sleeper LA, Cocke T, Hochman JS. **Acute myocardial infarction complicated by systemic hypoperfusion without hypotension: report of the SHOCK trial registry.** *Am J Med.* 2000;108(5):374-380. doi:10.1016/s0002-9343(00)00310-7
13. Naidu SS, Baran DA, Jentzer JC, et al. **SCAI SHOCK Stage Classification Expert Consensus Update: A Review and Incorporation of Validation Studies.** *J Am Coll Cardiol.* 2022;79(9):933-946. doi:10.1016/j.jacc.2022.01.018
14. Kohsaka S, Menon V, Lowe AM, et al. **Systemic inflammatory response syndrome after acute myocardial infarction complicated by cardiogenic shock.** *Arch Intern Med.* 2005;165(14):1643-1650. doi:10.1001/archinte.165.14.1643
15. National Institute for Health and Clinical Excellence. **Extracorporeal membrane oxygenation (ECMO) for acute heart failure in adults.** Interventional Procedures Guidance (IPG482) 2014
16. National Institute for Health and Clinical Excellence. **Acute heart failure: diagnosis and management.** Clinical Guideline (CG187) 2014 (updated 2021)
17. National Institute for Health and Clinical Excellence. **Chronic heart failure in adults: diagnosis and management.** Clinical Guideline (CG106) 2018
18. Levy MM, Rhodes A, Phillips GS, et al. **Surviving Sepsis Campaign: association between performance metrics and outcomes in a 7.5-year study.** *Crit Care Med.* 2015;43(1):3-12. doi:10.1097/CCM.0000000000000723
19. Royal College of Physicians. **National Early Warning Score 2: Standardising the assessment of acute-illness severity in the NHS. Updated Report of a Working Party.** 2017 [online] **https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2** (Accessed August 2022)
20. Faculty of Intensive Care Medicine. **Guidelines for the provision of intensive care services** 2019 [online] **https://www.ficm.ac.uk/sites/ficm/files/documents/2021-10/gpics-v2.pdf** (Accessed August 2022)

21. Cecconi M, De Backer D, Antonelli M, et al. **Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine.** *Intensive Care Med.* 2014;40(12):1795-1815. doi:10.1007/s00134-014-3525-z
22. Getting It Right First Time (GIRFT) **National Report on Cardiology.** [online] 2017 **https://www.gettingitrightfirsttime.co.uk/medical-specialties/cardiology/** (Accessed August 2022)
23. National Confidential Enquiry into Patient Outcome and Death. **Acute Heart Failure: Failure to Function.** 2018. [online] **https://www.ncepod.org.uk/2018ahf.html** (Accessed August 2022)
24. Baran DA, Grines CL, Bailey S, et al. **SCAI clinical expert consensus statement on the classification of cardiogenic shock.** *Catheter Cardiovasc Interv.* 2019;94(1):29-37. doi:10.1002/ccd.28329
25. Schrage B, Dabboura S, Yan I, et al. **Application of the SCAI classification in a cohort of patients with cardiogenic shock.** *Catheter Cardiovasc Interv.* 2020;96(3):E213-E219. doi:10.1002/ccd.28707
26. Jentzer JC, Henry TD, Barsness GW, Menon V, Baran DA, Van Diepen S. **Influence of cardiac arrest and SCAI shock stage on cardiac intensive care unit mortality.** *Catheter Cardiovasc Interv.* 2020;96(7):1350-1359. doi:10.1002/ccd.28854
27. Jentzer JC, van Diepen S, Barsness GW, et al. **Cardiogenic Shock Classification to Predict Mortality in the Cardiac Intensive Care Unit.** *J Am Coll Cardiol.* 2019;74(17):2117-2128. doi:10.1016/j.jacc.2019.07.077
28. Basir MB, Kapur NK, Patel K, et al. **Improved Outcomes Associated with the use of Shock Protocols: Updates from the National Cardiogenic Shock Initiative.** *Catheter Cardiovasc Interv.* 2019;93(7):1173-1183. doi:10.1002/ccd.28307
29. Tehrani BN, Truesdell AG, Sherwood MW, et al. **Standardized Team-Based Care for Cardiogenic Shock** [published correction appears in J Am Coll Cardiol. 2019 Jul 23;74(3):481]. *J Am Coll Cardiol.* 2019;73(13):1659-1669. doi:10.1016/j.jacc.2018.12.084
30. Chieffo A, Dudek D, Hassager C, et al. **Joint EAPCI/ACVC expert consensus document on percutaneous ventricular assist devices.** *Eur Heart J Acute Cardiovasc Care.* 2021;10(5):570-583. doi:10.1093/ehjacc/zuab015
31. Domingues CT, Milojevic M, Thuijs DJFM, et al. **Heart Team decision making and long-term outcomes for 1000 consecutive cases of coronary artery disease.** *Interact Cardiovasc Thorac Surg.* 2019;28(2):206-213. doi:10.1093/icvts/ivy237
32. Banning AP, Baumbach A, Blackman D, et al. **Percutaneous coronary intervention in the UK: recommendations for good practice 2015.** *Heart.* 2015;101 Suppl 3(Suppl 3):1-13. doi:10.1136/heartjnl-2015-307821
33. Moghaddam N, van Diepen S, So D, Lawler PR, Fordyce CB. **Cardiogenic shock teams and centres: a contemporary review of multidisciplinary care for cardiogenic shock.** *ESC Heart Fail.* 2021;8(2):988-998. doi:10.1002/ehf2.13180
34. Papolos AI, Kenigsberg BB, Berg DD, et al. **Management and Outcomes of Cardiogenic Shock in Cardiac ICUs With Versus Without Shock Teams.** *J Am Coll Cardiol.* 2021;78(13):1309-1317. doi:10.1016/j.jacc.2021.07.044
35. Garan AR, Kanwar M, Thayer KL, et al. **Complete Hemodynamic Profiling With Pulmonary Artery Catheters in Cardiogenic Shock Is Associated With Lower In-Hospital Mortality.** *JACC Heart Fail.* 2020;8(11):903-913. doi:10.1016/j.jchf.2020.08.012
36. Moran CG, Lecky F, Bouamra O, et al. **Changing the System - Major Trauma Patients and Their Outcomes in the NHS (England) 2008-17.** *EClinicalMedicine.* 2018;2-3:13-21. Published 2018 Aug 5. doi:10.1016/j.eclinm.2018.07.001
37. Huber K, Gersh BJ, Goldstein P, Granger CB, Armstrong PW. **The organization, function, and outcomes of ST-elevation myocardial infarction networks worldwide: current state, unmet needs and future directions.** *Eur Heart J.* 2014;35(23):1526-1532. doi:10.1093/eurheartj/ehu125
38. Patel BV, Barrett NA, Vuylsteke A; **NHS England-commissioned ECMO service for adults with respiratory failure. ECMO for Severe Acute Respiratory Distress Syndrome.** *N Engl J Med.* 2018;379(11):1090-1091. doi:10.1056/NEJMc1808731
39. Taleb I, Koliopoulou AG, Tandar A, et al. **Shock Team Approach in Refractory Cardiogenic Shock Requiring Short-Term Mechanical Circulatory Support: A Proof of Concept.** *Circulation.* 2019;140(1):98-100. doi:10.1161/CIRCULATIONAHA.119.040654
40. Alkhouli M, Alqahtani F, Cook CC. **Association between surgical volume and clinical outcomes following coronary artery bypass grafting in contemporary practice.** *J Card Surg.* 2019;34(10):1049-1054. doi:10.1111/jocs.14205
41. Pettit SJ, Jhund PS, Hawkins NM, et al. **How small is too small? A systematic review of center volume and outcome after cardiac transplantation.** *Circ Cardiovasc Qual Outcomes.* 2012;5(6):783-790. doi:10.1161/CIRCOUTCOMES.112.966630

42. Kumbhani DJ, Cannon CP, Fonarow GC, et al. **Association of hospital primary angioplasty volume in ST-segment elevation myocardial infarction with quality and outcomes.** *JAMA.* 2009;302(20):2207-2213. doi:10.1001/jama.2009.1715
43. Vallabhajosyula S, Dunlay SM, Barsness GW, Rihal CS, Holmes DR Jr, Prasad A. **Hospital-Level Disparities in the Outcomes of Acute Myocardial Infarction With Cardiogenic Shock.** *Am J Cardiol.* 2019;124(4):491-498. doi:10.1016/j.amjcard.2019.05.038
44. Shaefi S, O'Gara B, Kociol RD, et al. **Effect of cardiogenic shock hospital volume on mortality in patients with cardiogenic shock.** *J Am Heart Assoc.* 2015;4(1):e001462. Published 2015 Jan 5. doi:10.1161/JAHA.114.001462
45. England N Heart Transplantation Service (adults) Service Specification 170005/5. 2017 [online] **https://www.england.nhs.uk/wp-content/uploads/2017/04/heart-transplantation-service-adult.pdf** (Accessed August 2022)
46. Ali JM, Vuylsteke A, Fowles JA, et al. **Transfer of Patients With Cardiogenic Shock Using Veno-Arterial Extracorporeal Membrane Oxygenation.** *J Cardiothorac Vasc Anesth.* 2020;34(2):374-382. doi:10.1053/j.jvca.2019.05.012
47. Association of Anaesthetists of Great Britain and Ireland (AAGBI) **Inter-hospital transfer. Safety guideline** [online] **https://anaesthetists.org/Home/Resources-publications/Guidelines/Interhospital-transfer-AAGBI-safety-guideline** (Accessed August 2022)
48. Hofmann R, James SK, Jernberg T, et al. **Oxygen Therapy in Suspected Acute Myocardial Infarction.** *N Engl J Med.* 2017;377(13):1240-1249. doi:10.1056/NEJMoa1706222
49. Desta L, Jernberg T, Löfman I, et al. **Incidence, temporal trends, and prognostic impact of heart failure complicating acute myocardial infarction. The SWEDEHEART Registry (Swedish Web-System for Enhancement and Development of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies): a study of 199,851 patients admitted with index acute myocardial infarctions, 1996 to 2008.** *JACC Heart Fail.* 2015;3(3):234-242. doi:10.1016/j.jchf.2014.10.007
50. Taylor JA, Crowe S, Espuny Pujol F, et al. **The road to hell is paved with good intentions: the experience of applying for national data for linkage and suggestions for improvement.** *BMJ Open.* 2021;11(8):e047575. Published 2021 Aug 19. doi:10.1136/bmjopen-2020-047575
51. Wood A, Denholm R, Hollings S, et al. **Linked electronic health records for research on a nationwide cohort of more than 54 million people in England: data resource.** *BMJ.* 2021;373:n826. Published 2021 Apr 7. doi:10.1136/bmj.n826

Acronyms

AHFC	Advanced Heart Failure Centres
CS	Cardiogenic Shock
CPIP	Cardiac Pathway Improvement Programme
ECMO	Extracorporeal Membrane Oxygenation
FoCUS	Focused Cardiac Ultrasound
GIRFT	Getting It Right First Time
HACs	Heart Attack Centres
ICNARC	Intensive Care National Audit and Research Centre
LAUNCHES QI	Linking AUdit and National Datasets in Congenital HEart Services for Quality Improvement
MCS	Mechanical Circulatory Support
NEWS-2	National Early Warning Score
PPCI	Primary Percutaneous Coronary Intervention
SCAI	Society for Cardiovascular Angiography and Interventions
SWEDEHEART	Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies

Glossary

Acute coronary syndrome: a range of conditions, most commonly a myocardial infarction, where the blood flow that supplies the heart is reduced.
Arrhythmia: an irregular, abnormally fast or slow heart rate.
Bridge to decision: Use of short-term MCS in patients with cardiogenic shock until haemodynamics and end-organ perfusion are stabilized, contraindications for long-term MCS are excluded and additional therapeutic options including long-term MCS or heart transplant can be evaluated.
Bridge to candidacy: Use of MCS (usually LVAD) to improve end-organ function and/or to make an ineligible patient eligible for heart transplantation.
Bridge to transplantation: Use of MCS to keep a patient alive who is otherwise at high risk of death before transplantation until a donor organ becomes available.
Bridge to recovery: Use of MCS (short-term or long-term) to keep a patient alive until cardiac function recovers sufficiently to remove MCS.
Cardiac tamponade: compression of the heart by an accumulation of fluid in the pericardial sac.
Haemodynamic stabilization: normalisation or stabilisation of the blood flow from the heart with restoration of blood pressure, blood flow from the heart and the pressures inside the heart.
Hypoperfusion: inadequate blood supply, mainly due to low blood flow from the heart.
Invasive haemodynamic monitoring: the use of catheters to measure heart function and the pressures inside the heart.
Pulmonary embolism: a clot in the blood vessels that supply the lungs usually secondary to spread of a deep venous thrombosis (DVT, clot in the arms or legs).
Myocarditis: inflammation of the heart muscle.
Refractory shock: low blood pressure/hypoperfusion that does not respond to initial measures such as fluid administration and vasopressors.
Valve regurgitation: leaking of one of the heart valves which creates backwards instead of forwards blood flow from the heart.

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