Accreditation in the management of cardiac arrest in Spanish hospitals

CAPAC Project

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SOCIEDAD ESPAÑOLA DE CARDIOLOGÍA

SEMICYUC
LOS PROFESIONALES DEL ENFERMO CRÍTICO

Contents

ABBREVIATIONS

A.C. Autonomous Communities
AED: automated external defibrillator
AHA: American Heart Association
CA: cardiac arrest
CAPAC: cardiac arrest care certification
CAs: cardiac arrests
CAT: computerised axial tomography
CCCS/CNCCS/CCCTG: Canadian Recommendations
CEA: cost effectiveness analysis
CICU: cardiac intensive care unit
CPC: Cerebral Performance Category
CPR: Cardiopulmonary resuscitation
CRA: cardiorespiratory arrest
CVD: cardiovascular diseases
ECG: electrocardiogram
EEHT: economic evaluation of healthcare technologies
ERC: European Resuscitation Council
ICER: incremental cost-effectiveness ratio
ICU: intensive care unit
ILCOR: International Liaison Committee on Resuscitation
MRI: magnetic resonance imaging
mRS Modified Rankin scale
NICE: National Institute for Health and Care Excellence
NSI: National Statistics Institute
OHCA: out-of-hospital cardiac arrest
OHSCAR: Out of Hospital Spanish Cardiac Arrest Registry
PCI: percutaneous coronary intervention
QALY: Quality-adjusted life years
ROSC: Return of spontaneous circulation
ROSC: Return of spontaneous circulation
SEMICYUC: Spanish Society of Intensive Care Medicine, Critical Care and Coronary Units
SNS: Spanish National Health System
SVC: Servo-control
TTM: therapeutic temperature management

Chapter 1
EXECUTIVE SUMMARY

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Out-of-hospital cardiac arrest is a major public health problem worldwide. In Spain, it is estimated that **52,300 cardiac arrests occur annually, 30,000 in the community and 22,300 in hospitals**. Only 5-10% recover if they occur outside the hospital setting. It is estimated that of the 30,000 cardiac arrests in the community in Spain each year, just over 4,000 achieve spontaneous recovery of circulation and arrive alive at the hospital.

An **integrated care approach** for cardio-respiratory arrest (CRA) (chain of survival) is required, encompassing **activation of the emergency system and basic life support procedures by bystanders**, through **to advanced life support measures and post-resuscitation care**.

Cardiopulmonary resuscitation (CPR) within 3-4 minutes after cardiac arrest is essential to improve survival. Bystander CPR and the use of defibrillators has been shown to be a critical element of CPR. There is evidence that CPR that is witnessed has a higher chance of survival than CPR that occurs without any witnesses being present. In addition, numerous studies have shown that **cardiac arrest (CA) survival rates decrease if basic CPR is not initiated by bystanders** before the arrival of the professional teams. **Specific training in CPR** with chest compressions alone could increase such bystander CPR.

In recent years the Autonomous Communities have made significant investments in defibrillators in order to improve cardiac arrest survival rates. According to 2018 data, there are **a total of 23,000 defibrillators in Spain, five devices per 10,000 inhabitants**. Nevertheless, general population education has not been emphasized.

However, cardiopulmonary resuscitation does not end with the recovery of spontaneous circulation, but with the **return of normal brain function and complete stabilisation of the patient**. In-hospital management of cardiac arrest plays a critical role in the survival and, to an even greater extent, the neurological condition of the patient.

Furthermore, it should be noted that **poor neurological outcomes in patients with critical neurological** injury resulting from cardiac arrest can generate significant short- and long-term costs and, even though in-hospital survival has increased and neurological prognosis has improved over the last decade **(due to the widespread use of prognostic measures such as target temperature monitoring and post-resuscitation care)**, multidisciplinary teams are essential for providing overall quality management and ensuring continuity of care for these patients.

There is **considerable scope for action to reduce mortality and neurological damage in patients upon hospital discharge**, as indicated by the **wide variability in the management**

of cardiac arrest. This variability may be mainly due to epidemiological and socio-demographic factors, health resource allocation and reasons of methodology.

The recognition that cardiopulmonary resuscitation does not end with the recovery of spontaneous circulation, but with the return of normal brain function and complete stabilisation of the patient, will possibly help **to improve the therapeutic management of these patients** in intensive care units or cardiology intensive care units (CICU).

The *European Resuscitation Council* (ERC) has worked together with the European Society of Intensive Care Medicine (ESICM) in preparing **recommendations on post-resuscitation care**, highlighting the importance of high quality care as a vital link in the chain of survival and the good neurological state of the patients.

The first joint ERC-ESICM recommendations on post-resuscitation care were developed in 2015. These post-resuscitation care guidelines **were extensively updated in 2020** and incorporate the scientific evidence that has been published since 2015. The key points of the 2020 update of the ERC recommendations are as follows:

- In **patients with return of spontaneous circulation** (ROSC) after out-of-hospital cardiac arrest (OHCA) **without ST elevation** on the electrocardiogram (ECG), emergency cardiac catheterisation laboratory evaluation should be considered if there is an estimated high probability of acute coronary occlusion (e.g. patients with haemodynamic and/or electrical instability).
- Avoid **hypotension (<65 mm Hg)**. Average blood pressure target to achieve acceptable urine production (>0.5 mL kg^{-1} h^{-1}) and normal or declining lactate.
- **Targeted Temperature Management (TTM)** is recommended **for adults after OHCA** or in-hospital cardiac arrest (with any initial rhythm) who do not respond after ROSC. A target temperature must be maintained at a **constant value of between 32ºC and 36ºC** for at least 24 hours. Also, fever (>37.7ºC) should be avoided for at least 72 hours after ROSC in patients who remain in coma.
- In relation to general intensive care management, the **use of sedatives and short-acting opioids** is recommended. Avoid the use of a neuromuscular blocking drug routinely in patients undergoing TTM, but it can be considered in cases of severe shivering during TTM. Provide stress ulcer prophylaxis routinely in patients with cardiac arrest. Provide deep vein thrombosis prophylaxis. Obtain a target blood glucose level of 7.8 10 mmol L^{-1} (140-180 mg dL^{-1}) using an insulin infusion if necessary, **to avoid hypoglycaemia** (<4.0 mmol L^{-1} (<70 mg dL^{-1}). Initiate enteral feeding at low rates (trophic feeding) during TTM and increase after rewarming if indicated. If a TTM of 36ºC is used as the target temperature, trophic gastric feeding rates may be increased early during TTM. The use of prophylactic antibiotics is not routinely recommended.
- In a comatose patient with a motor response <3 within >72 h from ROSC, in the absence of confounding factors, an unfavourable outcome is likely when two or more of the following predictors are present: absence of pupillary and corneal reflexes at 72 hours, bilateral absence of the N20 cortical wave assessed by median nerve somatosensory evoked potentials at 24 hours, highly malignant EEG (background suppressed or burst-suppression) within >24 h, neuron-specific enolase >60 µg L^{-1} at 48 hours and/or 72 hours, myoclonic state <72 hours, or an extensive and diffuse anoxic lesion on brain imaging tests.

- Conduct functional assessments of physical and non-physical impairments prior to discharge from hospital to identify early rehabilitation needs and refer to rehabilitation if necessary. Organise the follow-up of all survivors of cardiac arrest within 3 months of hospital discharge, to include: screening for cognitive problems, screening for emotional problems and fatigue, providing information and support to survivors and family members.

The 2015 ERC also recommends **implementing accredited cardiac resuscitation units**. The recommendations propose the following:

- They should lead to **the creation of specialised** centres for cardiac arrest care.
- The minimum requirements are defined as the **possibility of immediate cardiac catheterisation and the ability to monitor temperature**.
- It would be advisable for them to be **equipped with the necessary means** for a **correct prognostic stratification**, and a **specific support and rehabilitation system** after hospitalisation.
- Ideally, they should be included in **organ donation programmes**, including asystole donation, for patients in whom resuscitation is unsuccessful or life support measures are withdrawn.
- The care of these patients is completed with access to units where **screening for hereditary diseases** is carried out for prevention in relatives. In order to optimise results and resources, it would be advisable to create **referral networks** for these centres.

ERC 2020 recommends the following:

- **Adult patients with non-traumatic OHCA** should be attended to in the **cardiac arrest centres** in accordance with local protocol.
- The minimum requirements for a cardiac arrest centre are the **24/7 availability** of an on-site coronary angiography laboratory, an emergency department, an ICU, imaging facilities such as echocardiography, computed tomography and magnetic resonance imaging.

The *American Heart Association's* (AHA) 2020 update has just been published, setting out new recommendations for CPR and emergency cardiovascular care. The new changes include, among others:

- The importance of **early initiation of CPR by lay responders** who activate the emergency system and initiate chest compressions while the victim is on a soft surface has been re-emphasised (despite recent advances, less than 40% of adults receive CPR initiated by non-physicians, and less than 12% use an automated external defibrillator (AED) before the arrival of out-of-hospital emergency services).
- The **improved algorithms and visual aids** offer easy-to-remember guidance for basic life support and advanced cardiovascular life support resuscitation situations.
- The use of **real-time audiovisual feedback** is suggested as a means to maintain the quality of CPR.
- Patient care after **return of spontaneous circulation (ROSC)** requires special attention to oxygenation, blood pressure control, assessment of percutaneous coronary intervention, specific temperature management and multimodal neuroprognosis.
- Because recovery from cardiac arrest continues long after the initial hospitalisation, patients must have a formal **assessment and support** in place to address their physical, cognitive and psychosocial needs.

The approach of this document reflects the alignment with the International Liaison Committee on Resuscitation (ILCOR) and the associated member councils.

In this scenario, the CAPAC **(Cardiac Arrest Care Certification)** project was born with the aim of achieving the **implementation of accredited cardiac resuscitation units in hospitals in Spain**, meeting the necessary quality standards to guarantee the best care for these patients and maximise survival and minimise possible neurological damage to the greatest extent possible.

In the first phase of the project, a review of the scientific evidence **(Annex 1)** was carried out to establish an opinion of the valid and available data from scientific research on the situation of cardiac arrest, in order to subsequently carry out a survey to determine the possible variability in clinical practice in the treatment of patients after cardiac arrest in the different Intensive Care and Cardiology Units of hospitals nationwide. This survey was led by the scientific committee of the CAPAC project, conducted online and disseminated by the Scientific Societies. There were a total of 115 participants (63.5% intensive care units, 36.5% multipurpose cardiology units). Based on the results of the survey, a cost analysis was conducted to determine the economic burden of cardiac arrest in Spain and the cost-effectiveness of cardiac arrest in relation to the measures recommended by the ERC based on the survey conducted for the project.

The main results of the survey show that **61.95% (1,630/2,631) of the patients under study survived**, but with **different neurological states associated upon discharge**: 719 patients (44.11%) were discharged from hospital with a very favourable neurological condition (CPC1), 407 (24.97%) with a favourable neurological condition (CPC2), 276 (16.93%) with an unfavourable neurological condition and 228 (13.99%) with a very unfavourable condition, CPC3 CPC4, respectively. These average percentages reported by the hospital show a **substantial improvement** in relation to those provided by the Ministry of Health taken from the **Out-of-Hospital Spanish Cardiac Arrest Registry (OHSCAR project)** in which the reported survival was only 38.1% (compared to 61.95% reported in this study's survey) and 10.9% survival in the CPC1-2 cerebral neurological scale category (compared to 69.1% reported in this study's survey).

The survey also shows that there is **enormous variability in both the resources available and the techniques employed** in the participating hospitals, which makes it difficult to implement the highest standards of post-resuscitation care, as defined in the international clinical guidelines. The variability is especially pronounced in temperature control and the use of advanced temperature control systems. This point is particularly noteworthy, because the existence and use of written protocols and advanced temperature monitoring systems results in better adherence to clinical guidelines and thus, more importantly, better neurological outcomes for patients.

The cost analysis based on the survey data shows an estimate of the cost of cardiac arrest for the participating hospitals of **approximately 84 million euros**, with higher average and total costs for **unfavourable** neurological states. The estimated cost of cardiac arrest for the national total and not just for the survey sample of this study would be in excess of **150 million euros**.

From the different ERC recommendations for out-of-hospital cardiac arrest, in this economic analysis based on the survey variability data, it is observed that **only temperature control using servo-control has a positive effect** on the proportion of patients in the various neurological states upon discharge, given that, in a simulated scenario compatible with the results of the population analysed, the difference in treatment in temperature control management with or without servo-control instruments resulted in a saving compared to the total sample of approximately **2.36 million euros (an average saving of 1,452 euros per patient treated) and a 2.85% saving compared to temperature control management with alternative techniques**. From a cost-effectiveness point of view in relation to the use of temperature servo-control techniques, the cost-effectiveness ratio is 2,118 euros per QALY gained (= 70.8 euros/0.563 QALYs). This value would suggest that **the servo-control techniques are clearly cost-effective**, especially as the figure obtained is nearly 10 times lower than the £20,000 established by the British NICE recommendations as the maximum threshold for new technologies to be accepted. It would also be substantially below the most recent estimates carried out in Spain through different methodological approaches.

The rationale behind the cost-effectiveness of this measure lies in **the reduction of patients with neurological damage (CPC3 and 4)** as shown in the following table of standardised ratios:

Standardised ratios				
	Estate of low cost		Estate of high cost	
	CPC1	CPC2	CPC3	CPC4
No servocontrol	0,379	0.248	0.217	0.156
With servocontrols	0,471	0.251	0.143	0.135

The implementation of sevocontrol techniques at national level would yield **estimated savings of 40 million euros**, from the year of cardiac arrest until the patient's death.

But most important of all, the implementation of servo-control techniques in all Spanish hospitals could mean that approximately **235 patients every year would avoid leaving hospital with severe neurological damage**.

The most important conclusion drawn from the results of the CAPAC project is the need to **implement nationally accredited cardiac resuscitation units that are involved in managing the cardiac arrest patient from admission until discharge from hospital**, meeting the quality standards required to guarantee the best possible care for these patients. Of particular importance would be the implementation of **servo-control techniques** in all these units so as to minimise the neurological damage to patients and to reduce costs to the health and social security system.

Executive summary

Cardiac arrests in Spain

52,300 cardiac arrests/year

- 30,000 cardiac arrests outside hospital
- 22,300 cardiac arrests in hospital

Survey results

Estimated number of patients who are alive on arrival at hospital
4,012

Estimated number of patients who survive until discharge
2,467 (61.95%)

Neurological states on discharge:

- 44.11% CPC1
- 24.97% CPC2
- 16.93% CPC3
- 13.99% CPC4

Variability in clinical practice in the management of post-cardiac arrest patients in Spanish hospitals

High variability in all areas of clinical management analysed, especially in TTM:

- Start-up of TTM control: 67.8%
- Place where started: 70.4% in ICU
- Start time: 50.4% after PCI
- Control techniques: only half use advanced SVC devices
- Target temperature: 54% fixed temperature, 27.5% temperature range

Standardised proportions

	Low cost scans		High cost scans	
	CPC1	CPC2	CPC3	CPC4
No servocontrol	0.379	0.248	0.217	0.156
With servocontrols	0.471	0.251	0.143	0.135

Estimated saving from implementation of servo control techniques at national level

40 million euros from the year os cardiac arrest to the death of patient

The start-up of SVC techniques in all Spanish hospitals could lead to approximately 235 patients each year avoiding leaving hospital with serious neurological damage.

CPC: Cerebral Performance Category; TTM: Targeted Temperature Management; ICU: Intensive Care Unit; PCI: Percutaneous Coronary Intervention; SVC: servo control.

Chapter 2
CONCEPTUAL FRAMEWORK

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Cardiac arrest (CA) is a major public health problem estimated to cause **more than three million out-of-hospital deaths** worldwide **each year**[1,2].

- In the USA **604,095 cardiac arrests** occur each year, of which 394,559 occur in the community and 209,566 in hospitals[1].
- In Europe, it is estimated that 624,708 cardiac arrests occur each year in the out-of-hospital setting, of which 426,246 are in European Union countries[1].
- In Spain, the exact incidence is not known, but it is estimated that 52,300 cardiac arrests occur annually, 30,000 in the community and 22,300 in hospitals, and may be responsible for an estimated **46,900 deaths per year, equivalent to an average of 128 per day**[1].

In most countries the results of cardiac arrest treatment **are not entirely satisfactory**. There is **considerable scope for action to reduce mortality from cardiopulmonary arrest**, as indicated by the **wide range of treatment outcomes**[3-9]. This variability may be mainly due to epidemiological and socio-demographic factors, health resource allocation and reasons of methodology[9].

- In **out-of-hospital cardiac arrest** (OHCA) there is a **significant difference in mortality rates between countries and between cities within the same nation**[3,6].
- The prognosis for **in-hospital cardiac arrests** varies, not only between hospitals and nations, but also according to the time and day of occurrence, with worse outcomes at night and on weekends[10,11].

In Spain, a recent study shows that **differences** in the incidence of resuscitation attempts, general characteristics and survival with good neurological state upon hospital discharge occur in OHCA cases attended by **pre-hospital emergency departments in different regions of Spain** (statistically significant differences were detected between emergency departments (p .0001) in the incidence of resuscitation attempts and all general characteristics except sex). Hospital treatments and outcomes also differed significantly[12].

It should also be noted that these performance results have changed due to the Covid-19 pandemic. A **decrease in OHCA survival** has been observed during the pandemic, perhaps due to a decrease in both bystander-initiated cardiopulmonary resuscitation (CPR) and combined use of CPR and automated external defibrillator (AED), coupled with increased response time by emergency services. An **increase in OHCA has also been observed in homes**, possibly due to the lockdown, and an **increase in cardiac arrests** in **younger** patients[13].

Early bystander-initiated cardiopulmonary resuscitation and the use of automated external defibrillator (AED) in the first minutes after cardio arrest are the 2 most determinant factors for CPR. This is why resuscitation should be started promptly, as recent studies show that approximately

90% of OHCAs die before hospital admission, only **10% are admitted to an emergency unit and less than 5% are discharged from hospital**[14].

At this point it should be noted that the **components and manoeuvres of resuscitation** are well known and are still very similar to those used years ago. There are even an increasing number of awareness campaigns for the correct care of cardiac arrest (first aid, basic life support, use of AEDs, etc.) and greater investment in defibrillators. In recent years the Autonomous Communities have made significant investments in defibrillators in order to improve cardiac arrest survival rates. According to 2018 data, there are a total of 23,000 defibrillators in Spain, five devices per 10,000 inhabitants[15]. But the integration of these components into a rapid and effective care system remains a challenge[1] and a **global strategy for cardio-respiratory arrest (CRA) care with the necessary local adaptations is needed**. In addition, it is imperative to draw attention to the **need to change some paradigms in order to efficiently address the challenge of cost** and the growing burden of this situation[16].

The presence of **poor neurological evolution, non-shockable rhythm, longer time from CA to the start of CPR procedure, advanced age** at the time of arrest and **reduced ejection fraction upon hospital discharge** are associated with worse vital prognosis at follow-up[14].

According to the **OHSCAR registry**, the out-of-hospital Spanish cardiac arrest registry (carried out between 2013 and 2014, with the latest cut-off in 2017-2018)[7,17]:

- 35.6% of patients with OHCA were transferred to hospital.
- Of these, 92.9% had a spontaneous pulse, 4.2% arrived with ongoing CPR with return of spontaneous circulation (ROSC), and 2.9% with ongoing CPR without ROSC. Of those with a pulse, **38.1% survived to be discharged**.
- The initial rhythm of the arrest was shockable in 22.8%.
- The majority of those attended were men (70.9%), with an average age of 64.2 years (63.1 for men and 66.8 for women).
- Prior defibrillation was performed by the first responder in 56% of cases.
- The results after resuscitation lead to a 64.4% rate of *exitus in situ*.

The OHSCAR registry data concludes that, upon discharge, there is a 10.9% survival rate in the brain neurological scale category CPC1-2[17]*. Another recent study indicates that survival without sequelae has increased by 25% between 2006 and 2020[18].

However, the high mortality rate is mostly due, in the majority of cases that do not reach the hospital, to ineffective CPR and, in those patients who regain spontaneous circulation and arrive at the hospital alive, **to neurological damage secondary to hypoxia, which in many cases is extensive and irreversible**[19].

However, cardiopulmonary resuscitation does not end with the recovery of spontaneous circulation, but with the return of normal brain function and complete stabilisation of the patient. In-hospital post-resuscitation care plays a critical role in survival and, to an even greater extent, in the neurological condition of the patient[19]. Good **CPR using defibrillators can achieve ROSC and get the patient to hospital alive**. But the **post-resuscitation care** of such a patient may involve the return or not of normal brain function and full stabilisation or not of the patient.

In fact, **hospital survival in Spain has increased and neurological prognosis has improved** over the last decade not only due to improved CPR techniques but also as a result of the improvement and spread of prognostic measures in hospitals such as target temperature control and post-resuscitation care. This is why it is essential to establish multidisciplinary teams that provide **integrated management and ensure continuity of care for these patients**[16].

The measure that has shown the greatest impact on patient prognosis is **Targeted Temperature Management (TTM)** by means of induced hypothermia maintained for a specified period of time. The benefits of TTM have been well established and for years it has been considered the **first-line treatment in patients recovering from cardiac arrest** for the prevention of neurological damage secondary to sustained anoxia[21].

Poor neurological outcomes in cardiac arrest patients generate significant **short and long-term costs**: Healthcare costs, such as increased length of stay in hospital and ICU, and non-healthcare costs, including lost productivity and disability allowance[22-26].

European Research Council Recommendations

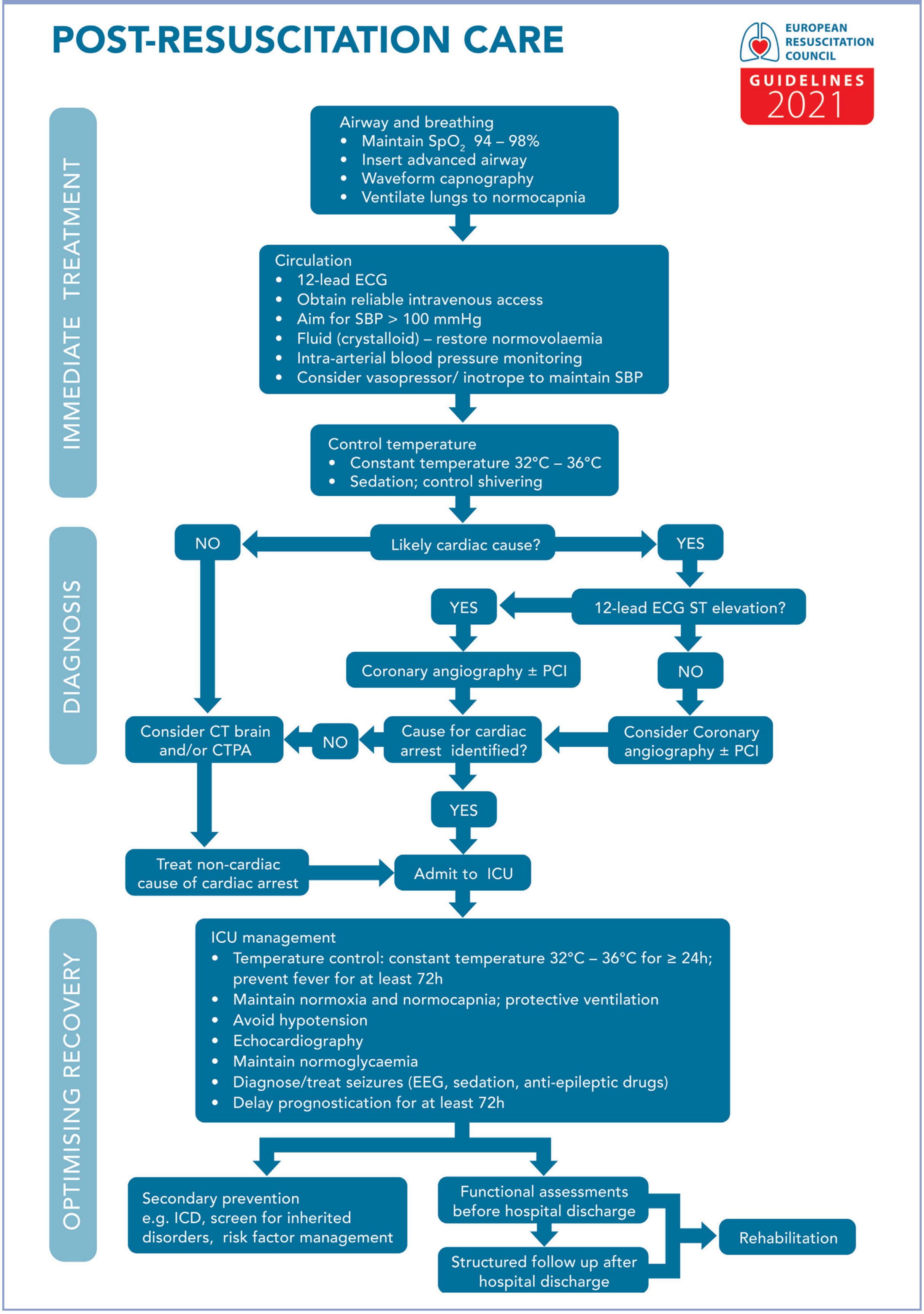
For years now, scientific evidence has been accumulating and clinical practice guidelines have been generated on **how to treat CRA and strategies to improve the final outcome** on survival and on the quality of the neurological recovery of patients. Proof of this is the commonality in the recommendations of international scientific institutions related to cardiac arrest, such as the *European Resuscitation Council* (ERC)[27-31], *American Heart Association* (AHA)[32-33], *International Liaison Committee on Resuscitation* (ILCOR)[34,35], *USA Institute of Medicine*[6], *Resuscitation Academy*[4], *Global Resuscitation Alliance*[3], CCCS/CNCCS/CCCTG *(Canadian Recommendations)*[36], Semicyuc (Spanish Society of Intensive Care Medicine, Critical Care and Coronary Units)[19]; on the basis of the **clinical trials** conducted, **meta-analysis and systematic reviews**[37-40].

The *European Research Council* has worked together with the *European Society of Intensive Care Medicine* in preparing recommendations on post-resuscitation care that recognise the importance of high quality care as a **vital link in the chain of survival and the good neurological state on discharge from hospital**.

The **post-resuscitation care algorithm** summarises some of the key interventions required to optimise the outcome for these patients[31].

**Scale Cerebral Performance Category (CPC): to determine the neurological evolution which form 5 categories: CPC1: Normal cerebral activity (aware, alert, capable of working), CPC2: Moderate cerebral discapacity, enough cerebral performance for day´s activities, capable of working in a protect enviroment, CPC3: Severe cerebral discapacity: aware, dependent of one another to function due to a deteriote cerebral function, CPC4: coma or vegetative state, CPC5: brain death, considering poor neurological result a CPC 3-5.*

Post-resuscitation care algorithm ERC-ESCIM 2020[31]



SBP: Systolic blood pressure; PCI: Percutaneous coronary intervention; CTPA: Computerised tomography angiography; ICU: Intensive care unit; EEG: electroencephalography; ICD: implantable cardioverter defibrillator.

The first joint ERC-ESICM recommendations on post-resuscitation care were developed in 2015. These post-resuscitation care guidelines **were extensively updated in 2020** and incorporate the scientific evidence that has been published since 2015. The key points of the 2020 update of the ERC recommendations are as follows[31]:

- In **patients with return of spontaneous circulation** (ROSC) after out-of-hospital cardiac arrest (OHCA) **without ST elevation** on the electrocardiogram (ECG), emergency cardiac catheterisation laboratory evaluation should be considered if there is an estimated high probability of acute coronary occlusion (e.g. patients with haemodynamic and/or electrical instability);
- Avoid **hypotension** (<65 mm Hg). Average blood pressure target to achieve acceptable urine production (>0.5 mL kg^{-1} h^{-1}) and normal or declining lactate;
- **Targeted Temperature Management (TTM)** is recommended **for adults after OHCA** or in-hospital cardiac arrest (with any initial rhythm) who do not respond after ROSC. A target temperature must be maintained at a **constant value of between 32ºC and 36ºC** for **at least 24 hours**. Also, fever (>37.7 ºC) should be avoided for at least 72 hours after ROSC in patients who remain in coma;
- In relation to general intensive care management, the **use of sedatives and short-acting opioids** is recommended. Avoid the use of a neuromuscular blocking drug routinely in patients undergoing TTM, but it can be considered in cases of severe shivering during TTM. Provide stress ulcer prophylaxis routinely in patients with cardiac arrest. Provide deep vein thrombosis prophylaxis. Obtain a target blood glucose level of 7.8 10 mmol L^{-1} (140-180 mg dL^{-1}) using an insulin infusion if necessary, to **avoid hypoglycaemia** (<4.0 mmol L^{-1} (<70 mg dL^{-1}). Initiate enteral feeding at low rates (trophic feeding) during TTM and increase after rewarming if indicated. If a TTM of 36ºC is used as the target temperature, trophic gastric feeding rates may be increased early during TTM. The use of prophylactic antibiotics is not routinely recommended;
- In a comatose patient with a motor response <3 within >72 h from ROSC, in the absence of confounding factors, an unfavourable outcome is likely when two or more of the following predictors are present: absence of pupillary and corneal reflexes at 72 hours, bilateral absence of the N20 cortical wave assessed by median nerve somatosensory evoked potentials at 24 hours, highly malignant EEG (background suppressed or burst-suppression) within >24 h, neuron-specific enolase >60 µg L^{-1} at 48 hours and/or 72 hours, myoclonic state <72 hours, or an extensive and diffuse anoxic lesion on brain imaging tests;
- Conduct functional assessments of physical and non-physical impairments prior to discharge from hospital to identify early rehabilitation needs and refer to rehabilitation if necessary. Organise the follow-up of all survivors of cardiac arrest within 3 months of hospital discharge, to include: screening for cognitive problems, screening for emotional problems and fatigue, providing information and support to survivors and family members.

The 2015 ERC also recommends implementing accredited cardiac resuscitation units. The recommendations propose the following[27]:

- They should lead to the **creation of specialised centres** for cardiac arrest care.
- The minimum requirements are defined as the **possibility of immediate cardiac catheterisation and the ability to monitor temperature**.
- It would be advisable for them to be **equipped with the necessary means for a correct prognostic stratification**, and a **specific support and rehabilitation system** after hospitalisation.

- Ideally, they should be included in **organ donation programmes**, including asystole donation, for patients in whom resuscitation is unsuccessful or life support measures are withdrawn.
- The care of these patients is completed with access to units where **screening for hereditary diseases** is carried out for prevention in relatives. In order to optimise results and resources, it would be advisable to create **referral networks** for these centres.

ERC 2020 recommends the following[31]:

- **Adult patients with non-traumatic OHCA** should be attended to in **the cardiac arrest centres** in accordance with local protocol.
- The minimum requirements for a cardiac arrest centre are the **24/7 availability** of an on-site coronary angiography laboratory, an emergency department, an ICU, imaging facilities such as echocardiography, computed tomography and magnetic resonance imaging.

References

1. Perales Rodríguez de Viguri N, del Nogal Sáez F. Consejo Español de Resucitación Cardiopulmonar (CERCP). Una estrategia para el sistema nacional de salud ante la parada cardiaca. Nuestra propuesta para salvar vidas y disminuir discapacidades. 2019. Disponible: https://www.cercp.org/images/stories/recursos/Documentos/propuesta_estrategia_parada_cardiaca.pdf. Acceso: marzo 2021.
2. Global Resuscitation Alliance. Disponible en: http://www.globalresuscitationalliance.org. Acceso: marzo 2021.
3. Global Resuscitation Alliance. Improving Survival from Out-of-Hospital Cardiac Arrest Acting on the Call. 2018 Update from the Global Resuscitation Alliance. Disponible en: http://www.globalresuscitationalliance.org/wp-content/pdf/acting_on_the_call.pdf. Acceso: marzo 2021.
4. Resuscitation Academy. 10 Steps for Improving Survival from Sudden Cardiac Arrest. Disponible en: https://static1.squarespace.com/static/5f74bfd9d36c8e051d674096/t/5f89e6c9eafad43a86436b88/1602873037807/10_steps_2019.pdf. Acceso: marzo 2021.
5. Declaration of the European Parliament of 14 June 2012 on establishing a European cardiac arrest awareness week. Disponible en: https://cercp.org/images/stories/recursos/2012/NOTICIAS/cercp/Declaracion_11_2012_del_Parlamento_Europeo_en_espaol.pdf. Acceso: marzo 2021.
6. Institute of Medicine; Graham R, McCoy MA, Schultz AM, editors. Strategies to Improve Cardiac Arrest Survival: A Time to Act. Committee on the Treatment of Cardiac Arrest: Current Status and Future Directions; Board on Health Sciences Policy; Washington (DC): National Academies Press (US); 2015 Sep 29. Disponible en: https://www.ncbi.nlm.nih.gov/books/NBK305685/. Acceso: marzo 2021.

7. Rosell-Ortiz F, Escalada-Roig X, Fernández Del Valle P, Sánchez-Santos L, Navalpotro-Pascual JM, Echarri-Sucunza A, et al. Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR). Resuscitation. 2017;113:90-95.

8. Perales N. Plan Integral ante la parada cardiaca hospitalaria. Un sistema para salvar vidas: recomendaciones. Arán Ediciones: Madrid, 2019. Disponible en: http://ediciones.grupoaran.com/urgencias-y-emergencias/518-Plan-integral-ante-la-parada-cardiaca-hospitalaria-Un-sistema-para-salvar-vidas-recomendaciones.html. Acceso: marzo 2021.

9. Socias Crespí L, Ceniceros Rozalén MI, Rubio Roca P, Martínez Cuellar N, García Sánchez A, Ripoll Vera T, Lesmes Serrano A. Epidemiological characteristics of out-of-hospital cardiorespiratory arrest recorded by the 061 emergencies system (SAMU) in the Balearic Islands (Spain), 2009-2012. Med Intensiva. 2015 May;39(4):199-206.

10. Peberdy MA, Ornato JP, Larkin GL, Braithwaite RS, Kashner TM, Carey SM, et al. Survival from in-hospital cardiac arrest during nights and weekends. JAMA. 2008;299:785–79.

11. Ofoma UR, Basnet S, Berger A, Kirchner HL, Girotra S; American Heart Association Get With the Guidelines – Resuscitation Investigators Trends in Survival After In-Hospital Cardiac Arrest During Nights and Weekends. J Am Coll Cardiol. 2018 :71(4):402-411.

12. Ruiz-Azpiazu JI, Daponte-Codina A, Fernández Del Valle P, López-Cabeza N, Jiménez-Fàbrega FX, Iglesias-Vázquez JA, et al. Regional variation in the incidence, general characteristics, and outcomes of prehospital cardiac arrest in Spain: the Out-of-Hospital Spanish Cardiac Arrest Registry. Emergencias. 2021 Feb;33(1):15-22.

13. Lai PH, Lancet EA, Weiden MD, Webber MP, Zeig-Owens R, Hall CB, et al. Characteristics Associated With Out-of-Hospital Cardiac Arrests and Resuscitations During the Novel Coronavirus Disease 2019 Pandemic in New York City. JAMA Cardiol. 2020 Jun 19;5(10):1154–63.

14. Rey JR, Caro-Codón J, Rodríguez Sotelo L, López-de-Sa E, Rosillo SO, González Fernández Ó, et al. Long term clinical outcomes in survivors after out-of-hospital cardiac arrest. Eur J Intern Med. 2020 Apr;74:49-54.

15. El mapa de espacios cardioprotegidos: España sigue a la cola de Europa en desfibriladores. Disponible en: https://www.vozpopuli.com/sanidad/equipos-desfribriladores-espacios-cardioprotegidos-espana_0_1322869041.html. Acceso: marzo 2021.

16. Fernández-de-Bobadilla J, López-de-Sá E. Carga económica y social de la enfermedad coronaria. Rev Esp Cardiol Supl. 2013;13(B):42-47.

17. Ministerio de Sanidad, Consumo y Bienestar Social. Registro OHSCAR. Disponible en: https://www.mscbs.gob.es/biblioPublic/publicaciones/recursos_propios/resp/revista_cdrom/Suplementos/ParadaCardiaca/RegistroOhscar.htm. Acceso: marzo 2021.

18. Marco I, Rosillo S, Merino C, Martín L, Martínez LA, Rodríguez L, et al. Evolución temporal del pronóstico tras parada cardio respiratoria en función de las actualizaciones de las guías de resucitación cardiopulmonar. Rev Esp Cardiol. 2020;73(Supl 1):121.

19. Martín-Hernández H, López-Messa JB, Pérez-Vela JL, Molina-Latorre R, Cárdenas-Cruz A, Lesmes-Serrano A, et al; miembros del Comité Directivo del Plan Nacional de RCP de la SEMICYUC. Managing the post-cardiac arrest syndrome. Directing Committee of the National Cardiopulmonary Resuscitation Plan (PNRCP) of the Spanish Society for Intensive Medicine, Critical Care and Coronary Units (SEMICYUC). Med Intensiva. 2010 Mar;34(2):107-26.

20. Cummins RO, Chamberlain DA, Abramson NS, Allen M, Baskett PJ, Becker L, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. A statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation. 1991 Aug;84(2):960-75.

21. Monsieurs KG, Nolan JP, Bossaert LL, Greif R, Maconochie IK, Nikolaou NI, et al; ERC Guidelines 2015 Writing Group. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation. 2015 Oct;95:1-80.

22. Greer DM, Funk SE, Reaven NL, Ouzounelli M, Uman GC. Impact of fever on outcome in patients with stroke and neurologic injury: a comprehensive meta-analysis. Stroke. 2008 Nov;39(11):3029-35.

23. Reaven NL, Lovett JE, Funk SE. Brain injury and fever: hospital length of stay and cost outcomes. J Intensive Care Med. 2009 Mar-Apr;24(2):131-9.

24. Diringer MN, Reaven NL, Funk SE, Uman GC. Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients. Crit Care Med. 2004 Jul;32(7):1489-95.

25. Ponsford JL, Spitz G, Cromarty F, Gifford D, Attwood D. Costs of care after traumatic brain injury. J Neurotrauma. 2013 Sep 1;30(17):1498-505.

26. Eunson P. The long-term health, social, and financial burden of hypoxic-ischaemic encephalopathy. Dev Med Child Neurol. 2015 Apr;57 Suppl 3:48-50.

27. European Resuscitation Council (ERC). European Resuscitation Council Guidelines for Resuscitation 2015 Resuscitation, 2015;95:1-311.

28. Fernández Lozano I, Urkía C, Lopez Mesa JB, Escudier JM, Manrique I, de Lucas García N, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Key Points. Rev Esp Cardiol (Engl Ed). 2016 Jun;69(6):588-94.

29. Soar J, Perkins GD, Maconochie I, Böttiger BW, Deakin CD, Sandroni C, et al. European Resuscitation Council Guidelines for Resuscitation: 2018 Update - Antiarrhythmic drugs for cardiac arrest. Resuscitation. 2019 Jan;134:99-103.

30. Nolan JP, Monsieurs KG, Bossaert L, Böttiger BW, Greif R, Lott C, et al. European Resuscitation Council COVID-19 guidelines executive summary. Resuscitation. 2020 Aug;153:45-55.

31. Nolan JP, Sandroni C, Böttiger BW, Cariou A, Cronberg T, Friberg H, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2021: Post-resuscitation care. Resuscitation. 2021 Apr;161:220-269.

32. Meaney PA, Bobrow BJ, Mancini ME, Christenson J, de Caen AR, Bhanji F, et al. CPR Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital A Consensus Statement From the American Heart Association. Circulation. 2013;128:(4):417-35.

33. Panchal AR, Berg KM, Hirsch KG, Kudenchuk PJ, Del Rios M, Cabañas JG, et al. 2019 American Heart Association Focused Update on Advanced Cardiovascular Life Support: Use of Advanced Airways, Vasopressors, and Extracorporeal Cardiopulmonary Resuscitation During Cardiac Arrest: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2019 Dec 10;140(24):e881-e894.

34. International Liaison Committee on Resuscitation (ILCOR). International Consensus on CPR and ECC Science With Treatment Recommendations (CoSTR) 2015. Resuscitation, 2015;95:e1-e621.

35. Soar J, Donnino MW, Maconochie I, Aickin R, Atkins DL, Andersen LW, et al; ILCOR Collaborators. 2018 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. Circulation. 2018 Dec 4;138(23):e714-e730.

36. Howes D, Gray SH, Brooks SC, Boyd JG, Djogovic D, Golan E, et al. Canadian Guidelines for the use of targeted temperature management (therapeutic hypothermia) after cardiac arrest: A joint statement from The Canadian Critical Care Society (CCCS), Canadian Neurocritical Care Society (CNCCS), and the Canadian Critical Care Trials Group (CCCTG). Resuscitation. 2016 Jan;98:48-63.

37. Holzer M, Bernard SA, Hachimi-Idrissi S, Roine RO, Sterz F, Müllner M; Collaborative Group on Induced Hypothermia for Neuroprotection After Cardiac Arrest. Hypothermia for neuroprotection after cardiac arrest: systematic review and individual patient data meta-analysis. Crit Care Med. 2005 Feb;33(2):414-8.

38. Arrich J, Holzer M, Herkner H, Müllner M. Hypothermia for neuroprotection in adults after cardiopulmonary resuscitation. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD004128.

39. Cullen D, Augenstine D, Kaper L, Tinkham S, Utz D. Therapeutic hypothermia initiated in the pre-hospital setting: a meta-analysis. Adv Emerg Nurs J. 2011 Oct-Dec;33(4):314-21.

40. Cheung KW, Green RS, Magee KD. Systematic review of randomized controlled trials of therapeutic hypothermia as a neuroprotectant in post cardiac arrest patients. CJEM. 2006 Sep;8(5):329-37.

Chapter 3
CAPAC PROJECT

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The CAPAC project **(Certification in Cardiac Arrest Care)** is led by a **scientific committee made up of the Spanish Society of Intensive Care (SEMYCIUC) and the Spanish Cardiology Society (SEC)**, and was created with the aim of improving hospital care for patients who have suffered cardiac arrest through the **accreditation of cardiac resuscitation units** in Spanish hospitals.

The ultimate goal is that, through the accreditation of these units, they will meet the highest quality standards required to guarantee the best care for these patients, maximising survival and the return of normal brain function and, with this, the total stabilisation of the patient.

The CAPAC project has consisted of four phases:

1. **Review of the scientific evidence** to determine which clinical practices have the greatest impact on survival and return of brain function in patients after cardiac arrest, especially those included in the ERC recommendations..
2. Conducting a **survey** on the processes in the treatment of patients after cardiac arrest in the different Intensive Care and Cardiology Units of hospitals nationwide **in order to ascertain the possible variations in clinical practice**. This survey was led by the scientific committee of the CAPAC project, conducted online and disseminated by the Scientific Societies.
3. Cost analysis of the variability in clinical practice, based on the survey data, in order to determine the economic burden of variability in the treatment of patients after cardiac arrest in Spain, as well as the cost-effectiveness of this in relation to the measures recommended by the ERC.
4. Position paper of the Societies Participating in the project regarding the need for the creation and accreditation of post cardiac arrest units in Spanish hospitals.

It should be borne in mind that this study is based on a questionnaire with individual responses that do not necessarily have to coincide with the registered data of the participating centres. It is therefore susceptible to potential response bias. The survey design includes a large number of hospitals from almost all over Spain, although it was not randomly sampled. The results are therefore susceptible to potential selection bias. Lastly, it should also be noted that, given the pandemic situation and the impact of Covid-19 on patient care, it was decided to conclude the survey with 83% of the total national representativeness.

Chapter 3.1
NATIONAL SURVEY ON PROCESSES, STRUCTURE AND CLINICAL PRACTICE IN INTENSIVE CARE UNITS/CARDIAC UNITS

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Since the advent of CPR over 40 years ago, an increasing proportion of patients with cardiopulmonary arrest have achieved ROSC. However, most of these patients still die within the first few days of admission to **critical care units, ICU or CICU**, and this situation has not improved in recent years[1].

Surviving patients need **specific care in intensive care units**, focused on avoiding haemodynamic compromise and initiating early cardiac rehabilitation. The **patient is at the centre of the care** provided by the multidisciplinary healthcare team. To ensure the quality of care, professionals must speak a common language, create objectives and plan interventions that are carried out in the same way and with the same frequency by each of the professionals.

Objective

To find out the variation in clinical practice, structure and processes in the treatment of patients after cardiac arrest by means of a survey carried out in the ICU and Cardiology departments of hospitals nationwide.

Methodology

The survey was designed to be answered on-line. A series of questions with closed answers were posed so as to gather the information considered to be of interest for the objectives set. The questions dealt with the **indicators that define the requirements of resuscitation units**, based on the ERC Guidelines. The questions were divided into the following blocks:

- Care of comatose patients after out-of-hospital CRA in ROSC patients.
- Structure of the units.
- Temperature control management.
- Prognosis.

The survey is shown in **Annex 2**.

Representativity was sought at national level, with a confidence interval of 95% and a margin of error of 5%. The survey was mostly answered by Heads of Department (44%).

The statistical analysis of the data consisted of a descriptive presentation of the parameters analysed. Statistical processing of the data was carried out with the IBM SPSS Statistics 20.0.0 package for Windows.

Results

The survey was disseminated by the Scientific Societies. A total of 115 participants (73 from intensive care units/polyvalent units (63.5%) and 42 from cardiology (36.5%)) completed the survey between March and September 2020.

The results of the survey are reflected in tables 1-4 in Annex 3. Most of the participants are from the Community of Madrid and Catalonia. The results show that the average number of critical care unit beds in participants' hospitals is 16 and the average number of admissions of comatose patients due to out-of-hospital cardiac arrest per year is 24.

One of the **significant results** of the survey shows that **61.95%** (1,630/2,631) of the patients under study survive, but with different neurological states associated upon discharge: 719 patients (44.11%) left the hospital with a very favourable neurological condition (CPC1); 407 (24.97%) with a favourable neurological condition (CPC2); 276 (16.93%) in an unfavourable neurological condition (CPC3) and **228 (13.99%) in a very unfavourable condition (CPC4)**.

Discussion

The complex pathophysiological processes that occur after whole-body ischaemia during cardiac arrest and the subsequent reperfusion response during cardiopulmonary resuscitation and after successful resuscitation have been termed **post-cardiac arrest syndrome**[2]. Depending on the cause of the arrest, and the severity of the post cardiac arrest syndrome, many patients will require multiple organ support and the treatment they receive during this post-resuscitation period **significantly influences overall outcomes and particularly the quality of neurological recovery**[2-4].

Protocols

The most significant result of the survey is the enormous variability in both the resources available and the techniques employed in the participating hospitals, which makes it difficult to implement the highest standards of post-resuscitation care, as defined in the international clinical guidelines.

A standardised protocol for post-cardiac arrest care is needed. Recent studies and clinical guidelines recommend the treatment of these patients using **goal-directed protocols**, including therapeutic measures that have proven to be effective, such as mild therapeutic **induced hypothermia and early revascularisation**, when indicated, as it can significantly improve the prognosis of these patients[1,5,6].

It is recommended that standard TTM protocols are established and implemented **using multidisciplinary teams and strategies**. Despite the recommendations for TTM, hospital adherence to guidelines remains low, perhaps due to lack of equipment, experience, predisposed notions of increased workload and difficulty, scepticism and limited implementation strategies[2,7,8].

Thus, we see in the results of the variability analysis that more than 24% of the participants do **not have a post-cardiac arrest** protocol in the participating units, although practically all the participants do have an organ donation protocol, which is equally costly in terms of the need for resources, increased workload, etc. and which, to a large extent, is complementary to the other

The average annual patient outcome upon discharge by neurological condition is 24 patients with CPC1, 15 CPC2, 12 CPC3, 8.3 CPC4 and 35 CPC5 (death). However, if we analyse the results according to whether or not they have a written protocol and use servo-controlled TTM systems, we see that these averages change significantly:

	CPC1	CPC2	CPC3	CPC4
No protocol. No TTM	22.3	16.4	15.1	7.6
No protocol . Basic TTM	24.4	15.5	14.3	7.8
No protocol. Advanced TTM	25.0	16.3	10.4	8.3
Protocol. Basic TTM	24.8	14.4	17.5	12.9
Protocol . Advanced TTM	26.0	15.4	8.7	8.4

Hence, centres with a written protocol have a higher average number of patients with CPC1 on discharge compared to those without (22.3 vs. 24.8). If, despite not having a written protocol, the centre incorporates some basic TTM measures, their results rise to 24.4 and increase even more (25) if they incorporate advanced TTM systems.

Lastly, we can see that centres that have a written protocol and also use servo-controlled systems for TTM therapy have reported better data in terms of patients with CPC1 on discharge, as well as lower numbers of patients in CPC3 and 4, which implies serious sequelae for them and has, secondarily, important economic consequences for the health system.

We have already seen in the previous table the improvement in patients' neurological outcomes resulting from the application of a written protocol in the survey conducted. **The protocol promotes adherence to the technique, its application to a larger number of patients, the standardisation of post-resuscitation care in each centre, the auditing of results and the implementation of improvement measures** to further increase the quality of the care provided.

Despite the limitations of the sample under analysis, the data highlights the importance of a complete protocol and the adoption of advanced neuroprotection systems for the adequate implementation of critical post-arrest care, which allow the permanent monitoring of the patient's temperature and the safe and effective application of TTM therapy. This conclusion is in line with the most recent recommendations of clinical practice guidelines on the subject.

Diagnosis

The possible cause of the patient's situation must be diagnosed. If it is a possible cardiac cause with ST-segment elevation in 12-lead electrocardiogram (ECG), it is important to perform urgent coronary catheterisation and percutaneous coronary intervention (PCI). Without ST-segment elevation, it needs to be considered. The ERC 20209 recommendation indicates that, in patients with ROSC after out-of-hospital cardiac arrest without ST-elevation on ECG, an emergency cardiac catheterisation laboratory evaluation should be considered when there is an estimated high probability of acute coronary occlusion (e.g. patients with haemodynamic and/or electrical instability). A recent randomised controlled trial showed no difference in survival at 90 days after out-of-hospital cardiac arrest due to ventricular fibrillation among patients without ST-elevation on ECG assigned to an immediate coronary angiography versus a delayed angiography[10].

Once the cause of cardiac arrest has been identified, the patient should be admitted to the Intensive Care Unit. If causes have not been identified consideration should be given to performing a computerised tomography (CT) scan and/or a CT pulmonary angiogram, followed by treatment of the possible non-cardiac causes[9].

Despite its importance, around **25% of participants indicate that they do not perform coronary angiography and emergent PCI**. And almost 50% of participants indicate that they do not have a screening protocol for arrhythmogenic conditions.

For the most part, these centres that do not do coronary angiography and PCI are small centres that either do not have a cardiology service or do not have a 24-hour cardiology service, so they send the patient to another centre for haemodynamic treatment and then receive the patient back in their ICU for TTM and recovery. Obviously, this causes delays and disruptions in the application of the TTM and could impair its results compared to those who have permanent availability for carrying out this type of intervention on their own premises.

Most of the participants have a time target for initiating PCI (77.4%) and almost 80% measure it regularly, 2 hours being the most common and widespread time limit.

The rapid detection of the cause of the arrest and, if necessary, the performance of the relevant coronary intervention within the period recommended by the clinical guidelines (the above-mentioned 2 hours) has a **significant impact on the prognosis of patients**, since it allows the corrective measures for primary damage to be applied more quickly and, in addition, allows measures to prevent secondary damage to be applied more quickly, including temperature control.Continuous monitoring of the patient to immediately detect possible febrile peaks and avoid their adverse effects is essential in order to **optimise the neurological prognosis of post-arrest patients**.

Temperature control

Patients with critical neurological injury may suffer secondary neurological damage involving multiple destructive processes[11-13]. Primary and secondary induced damage can play a role in disrupting thermoregulatory brain functions and result in a dysregulated temperature and neurogenic fever[13-15]. It should also be mentioned that patients with a fever after a cardiac arrest have more likelihood of developing disabilities than those who do not have a fever[16-21]. Neurogenic fever is also common in stroke patients and is associated with poor clinical outcomes, including permanent neurological disabilities (commonly measured by the modified Rankin Scale (mRS)) and death[19,22-25].

The recommendations made up to now by the different Scientific Societies, such as the AHA *(American Heart Association)*[26], ILCOR *(International Liaison Committee on Resuscitation)*[27,28], CCCS/CNCCS/CCCTG (Canadian Recommendations)[29], SEMYCIUC (Spanish Society of Intensive Care Medicine, Critical Care and Coronary Units)[1] based on the clinical trials conducted, meta-analyses and systematic reviews[30-34], as well as the current position of the European Resuscitation Council[2,9,35-37], recommend **TTM to help protect patients´neural functions** and improve patient outcomes. The level of acceptance and implementation of TTM varies (currently in Spain it is used in less than 20% of candidates), but the groups that have adopted this strategy have achieved good results[38].

The National CPR Plan of the Semicyuc recommends the implementation of this measure to protect against neurological sequelae, which has proven its efficacy, pending the emergence of new evidence or work currently underway (numerous clinical trials in the recruitment phase)[1].

The most important element to highlight, in relation to the application of prognostic measures, is temperature control. The survey shows that **most of the participants perform active temperature control in the ICU, after an out-of-hospital cardiac arrest with ROSC in all patients**. Some participants indicate that this control begins in the emergency room, cardiac units or cardiac catheterisation laboratory. However, the majority **indicate that they do not have a target time for the start of TTM** and that they control temperature with catheters or hydrogel patches with advanced servocontrol devices, but a significant percentage indicate that they use physical measures (cold compresses, fans/physical measures).

The definition of what is meant by active temperature control was not included in the analysis. At this point, it should be noted that TTM can be broadly defined as any voluntary attempt to regulate a patient's temperature within a specific target, for a specific period of time, to improve patient outcomes. ERC 2020 recommendations indicate that **active temperature control is required to achieve and maintain a constant temperature of between 32ºC and 36ºC for at least 24 h** in adult patients after out-of-hospital or in-hospital arrest (with any initial rhythm) who do not respond after ROSC[9].

As shown by the results of the variability analysis, **more than 32% of the participants did not actively monitor temperature** in the ICU after out-of-hospital cardiac arrest with ROSC in all patients. It should be noted that approximately **30% of the participants indicated that this monitoring is initiated in the emergency department, cardiac units, or cardiac catheterisation laboratory**.

When to carry out TTM

The practical application of TTM is divided into three phases: induction, maintenance and re-warming. The majority of participants indicate that TTM is initiated after PCI, but there is a considerable percentage who indicate that it is performed before or during.

The ERC 2020 management algorithm9 indicates constant temperature control post PCI. From the results obtained in the variability analysis, it seems that the actual TTM is carried out later, but in some centres, prior cooling measures are applied before starting the neurological protection measures. It should be pointed out that temperature management with non-targeted measures, such as anti-pyretic medicines, has limited effectiveness and precision for reaching/maintaining specific temperatures and may represent unnecessary costs[39-41].

The above recommendations suggest that cooling should begin as soon as possible after ROSC, but this recommendation is only based on preclinical data and reasonable assumptions. Pre-hospital cooling by rapid infusion of large volumes of cold intravenous liquid immediately after ROSC is not recommended[2,9].

It should be noted that the majority of the participants (62.5%) indicated that they do not have a time target for the initiation of TTM, so the **existence of an actual protocol in the units, its updating or auditing and the monitoring of its applicability** (only half indicated that their unit has a written protocol) is essential.

TTM target temperature

The ERC 2020 establishes a target temperature in the range of 32-36ºC as soon as possible, for more than 24 hours, preventing fever for at least 72 hours[9]. It must be clarified that when we talk about a range, this does not mean that the temperature fluctuates between 32ºC and 36ºC, but that a specific figure is chosen (e.g. 34ºC) and maintained for the duration of this patient's treatment, according to their needs. If, for any specific reason (haemodynamic alterations, for example) the patient does not tolerate the target set, it can be readjusted (e.g. by raising it to 35ºC). For a new patient, the situation is reassessed and a different temperature within the interval can be chosen. In the protocol, if one exists, the **criteria for choosing one or the other will be defined**. The treatment is thus individualised, but the benefits of a protocol are also taken advantage of.

External and/or internal cooling techniques can be used for starting and maintaining TTM. If a specific target temperature is chosen, for the many patients who arrive at hospital after a cardiac arrest with a temperature lower than the established target temperature, advanced TTM systems can be used, which make it possible to warm the patient up and return them to the desired temperature in a simple, controlled manner. When using a 36°C target, the reheating phase will logically be shorter.

The results of the variability analysis indicate that the majority of participants (75.7%) have a target temperature. Just over half have a fixed target temperature, 36% at 33 degrees, while 27.5% use a target temperature within the range of 34-36 degrees. The majority of participants who indicates that they have a target time for the commencement in the majority of cases is more than 60 minutes.

Taking into account the neurological damage that sudden temperature changes and especially fever can cause in these patients, **the continuous monitoring that servo-controlled systems offer, together with their immediate therapeutic reaction, make these systems, a priori, result in greater neuroprotection** and lead (as shown in the table above) to better CPC results.

However, the variability analysis suggests that not all units currently treating such patients have the most advanced means of applying TTM.

TTM methods

The ideal TTM method is not well established in the literature[2,29,42,43]. However, it is clear that fast, accurate and easy-to-use temperature control should be implemented. Guideline recommendations and safety profiles are not the same across TTM methods and may differ in their ability to facilitate compliance with hospital protocols and have significant clinical and economic implications[2,24,29,40,44,45]. Each TTM method has a specific set of strengths and limitations with respect to performance, safety and beneficial functions/programmes[46].

Methods to induce and/or maintain TTM include: simple ice packs and/or wet towels (iced liquids alone cannot be used to maintain hypothermia), cooling blankets or pads, water or air circulation blankets, water circulation gel-coated pads, transnasal evaporative cooling, intravascular heat exchanger, and extracorporeal circulation. The ERC states that for TTM after cardiac arrest, simple ice packs and/or wet cloths are cost-effective. However, these methods can be more time-consuming for nursing staff, can result in greater temperature fluctuations and do not allow for controlled rewarming[2], and are therefore discouraged by the guidelines as a suitable TTM system.

Advanced TTM methods can provide precise temperature control with fewer fluctuations, thus improving adherence to the guides[17,45,46]. Automated cooling devices can enable better adherence to guidelines and reduce the burden on critical care resources and can improve patient outcomes[7,8,47]. In addition, in many cases, they allow auditing of the results by recording and analysing the TTM treatment performed, which contributes to improving clinical practices and reinforces adherence to the protocol and the technique.

In general, according to the recent 2017 Neurocritical Care Society guidelines, temperature modulating devices with servo-control mechanisms are the superior method for inducing hypothermia and avoiding sustained fever after injury, and there is evidence to suggest that temperature variability during the maintenance phase can be reduced by the use of intravascular pads and gel surface devices.[50]

In the variability analysis, we observed that approximately half of the participants indicate that they control their temperature with catheters or hydrogel patches (advanced servo-control devices) and slightly more than 50% of the participants indicate that they use physical measures (cold packs, fans/physical measures). A number of hospitals use both measures and modulate them, starting first with physical measures and then, in cases where these are not sufficient, moving to advanced systems. This is probably done on cost grounds. It would be interesting to know at what point servo-controlled measures are initiated and under what criteria they are applied.

Again, the **heterogeneity of clinical practice** in this respect is evident, with centres having the most advanced technology, recommended by clinical guidelines, and others continuing to use traditional means, with lower efficacy and a heavier workload for the units.

Regardless of the cooling method chosen, scientific evidence shows that TTM is easily performed and has no serious side effects or complications associated with mortality.[51] Rebound hyperthermia is associated with a worse neurological outcome. Therefore, in the rewarming phase, rewarming must be achieved slowly: the optimal speed is unknown, but the consensus is currently around 0.25-0.5ºC of rewarming per hour. Choosing a strategy of 36ºC will reduce this risk[2].

In the variability analysis, 68.7% indicate that they perform temperature recovery after TTM as indicated in the clinical guidelines, while the other 31.3% do not perform it..

There is also no homogeneity in terms of the speed at which this reheating is carried out, since while 52.2% of them do it with a rewarming speed of 0.1-0.25ºC/h, 16.5% do it at a higher speed (0.26-0.50ºC/h)

Prognosis

There is a wealth of published data on prognosis since the 2015 ERC guidelines. The two-stage prognostic algorithm in the 2015 guidelines has been simplified so that an unfavourable outcome is deemed likely when two or more of the listed predictors are present. The algorithm is valid for comatose patients with a Glasgow motor score of 3 (compared to 2 in the 2015 version). A threshold value for neuron-specific enolase is now indicated. EEG pattern suppression and burst-suppression are the most consistent predictors of a poor neurological outcome. In contrast, the absence of EEG reactivity has only been inconsistently associated with poor neurological outcome in recent studies[9].

Prognosis should carried out using a **multimodal strategy (using clinical examination, electrophysiology, biomarkers and imaging)**[9] .Current resuscitation guidelines generally recommend an assessment of neurological prognosis and decision on treatment no earlier than 72 hours after ROSC[52] and only after excluding confounding factors such as metabolic disturbances or the effects of residual sedation and muscle relaxants. Subsequently, the patient's best response to painful stimuli is assessed according to the motor score of the Glasgow Coma Scale (GCS-M) as a screening criterio[53]. A Glasgow motor score of 3 (abnormal or worse flexion in response to pain) at 72 hours or later after ROSC may identify patients for whom a neurological prognosis may be necessary[9]. In patients who remain comatose 72 hours or later after ROSC, the following tests may predict a poor neurological outcome: bilateral absence of standard pupillary light reflex, quantitative pupillometry, bilateral absence of corneal reflex, presence of myoclonus within 96 hours and, in particular, myoclonus status within 72 hours[9].

One in three patients may have a delayed recovery of consciousness (72 hours after initiation of TTM and discontinuation of sedation) and 23% remain comatose one week after admission. Between 15-30% of patients with a good prognosis wake up between 48 hours and 10-12 days after discontinuation of sedation[35,54].

It should be noted that the lower the target temperature was within the range of 32-36°C, the longer the wait should be, as cooling to a lower target temperature may influence a delayed neurological recovery. Therefore, discontinuation of life-sustaining treatment should be delayed for more than 5 days in patients cooled to 33ºC or less[55].

However, it should be noted that late awakening is common and often has a good neurological outcome. Studies show that late prognosis is significant for a minority of patients and is related to later decisions on level of care with **effects on the ICU length of stay, survival time and outcome**[56,57].

In the analysis of variability, the majority of the participants (67.8%) indicate that they do not apply prognostic scales within the first 72 hours and that (55.6%) carry out the neuroprognosis 72 hours after the arrest. However, it should be noted that if there is no time target for starting TTM, the patient may continue therapy 72 hours post cardiac arrest. 24% indicate that they perform neuroprognosis 72 hours after rewarming, which already provides for the possibility of a late initiation of TTM and 22% have no set time.

In the analysis, the vast majority of participants (over 90%) carry out neurological examinations and EEG. The GOS (Glasgow Outcome Scale) to assess degrees of disability is only used by 61.7% of participants. However, very few centres admit to monitoring these patients (28.7%), while the rest of them (71.3%) do not do so. This circumstance makes it difficult to detect inefficiencies and to implement measures to improve the procedures since the potential medium/long term benefit that they will have for these patients is unknown.

Thus, we see once again the enormous variability we encounter in daily practice in our hospitals, including when determining the neurological condition of these patients, the best time to do so and the most efficient method.

Monitoring and rehabilitation

Although the neurological outcome is considered good for most survivors of cardiac arrest, cognitive and emotional problems and fatigue are common. Long-term cognitive impairments are present in half of the survivors[2].

Functional assessments of physical and non-physical impairments should be conducted prior to discharge from hospital in order to identify early rehabilitation needs and to refer to rehabilitation if necessary[9].

Organisation of the follow-up after cardiac arrest is necessary and and should be systematically organised , despite it varies widely between hospitals and countries. Follow-up of all cardiac arrest survivors needs to be organised within 3 months of hospital discharge, to include: screening for cognitive problems, screening for emotional problems and fatigue and providing information and support to survivors and family members[9].

Certain characteristics of the patient could be used to predict spontaneous recovery in the early post-ROSC period. Therefore, the optimal timing of initiation of TTM could be re-evaluated.

However, the diversity of types, sizes and resources of the units that care for this type of patient at present, the care burdens that they support and, in general, their lack of specialisation in post-arrest care, make it difficult to provide adequate follow-up care for these patients. A **network of specialist centres, with programmes focused specifically on these types of patients, would undoubtedly be more efficient in this area**.

Unit structures

The new international guidelines recommend the treatment of resuscitated patients in what are known as resuscitation or cardiac arrest centres, which are structurally, organisationally and logistically geared specifically towards the care of these patients[58]. In Spain, this system is not used as much and post-cardiac arrest recovery care revolves around post-resuscitation care administered in the critical care units, essentially the ICU and CVICU.

The CICU units have the technical and human resources necessary for the care and continuous monitoring of potentially recoverable cardiological critical patients[59] , while the ICU cover a wider field, focused not only on cardiovascular diseases.

The ICU is defined as an organisation of healthcare professionals offering multidisciplinary care in a specific area of the hospital, which meets functional, structural and organisational requirements, in such a way that it guarantees the appropriate conditions of safety, quality and efficiency to care for patients who, being susceptible to recovery, require support due to some kind of organ dysfunction or need monitoring in life-threatening situation[60].

There is hope based on the fact that, through these criteria developed jointly by the main parties involved in this care, the structure of the processes can be combined and pre-clinical/clinical interconnection can be promoted following satisfactory primary resuscitation and the subsequent processes in the clinics can be professionalised and optimised as far as possible[61].

The results of the survey indicate that the majority of participants have access to PCI, ultrasound, computed tomography and cardiology services, 24 hours a day, 7 days a week. EEG and neurophysiology services are also available, but with a restricted timetable.

Conclusions

The results of this analysis show that there is a **wide margin for action in patients with cardiac arrest**, as indicated by the **variability of the results in relation to processes, structure and**

clinical practice in intensive care units/cardiac units in Spain, so that **standardised and goal-driven protocolisation** is necessary, including therapeutic measures that have proven to be effective, such as **mild induced therapeutic hypothermia and early revascularisation**, when indicated, as it can significantly improve the prognosis of these patients.

In this respect, in view of the results of the variability survey, we can conclude that:

- **There is enormous variability in both the resources available and the techniques employed, which makes it difficult to implement the highest standards of post-resuscitation care, as defined in the international clinical guidelines**.
- The **existence and use of written protocols and advanced temperature monitoring systems** results in better adherence to clinical guidelines and thus, more importantly, **better neurological outcomes for patients**.
- The creation of a **network of accredited centres for post-resuscitation care may prove to be definitive** in reducing the variability detected, making it possible to homogenise resources and techniques, optimise their use and ensure that all patients are provided with the best possible post-arrest care. This will undoubtedly bring clinical benefits for patients and, as we will see below, also economic benefits for the national health system.

References

1. Martín-Hernández H, López-Messa JB, Pérez-Vela JL, Molina-Latorre R, Cárdenas-Cruz A, Lesmes-Serrano A, et al; miembros del Comité Directivo del Plan Nacional de RCP de la SEMICYUC. Managing the post-cardiac arrest syndrome. Directing Committee of the National Cardiopulmonary Resuscitation Plan (PNRCP) of the Spanish Society for Intensive Medicine, Critical Care and Coronary Units (SEMICYUC). Med Intensiva. 2010 Mar;34(2):107-26.
2. Nolan JP, Soar J, Cariou A, Cronberg T, Moulaert VR, Deakin CD, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines for Post-resuscitation Care 2015: Section 5 of the European Resuscitation Council Guidelines for Resuscitation 2015. Resuscitation. 2015 Oct;95:202-22.
3. Monsieurs KG, Nolan JP, Bossaert LL, Greif R, Maconochie IK, Nikolaou NI, et al; ERC Guidelines 2015 Writing Group. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation. 2015 Oct;95:1-80.
4. Rosell-Ortiz F, Escalada-Roig X, Fernández Del Valle P, Sánchez-Santos L, Navalpotro-Pascual JM, Echarri-Sucunza A, et al. Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR). Resuscitation. 2017;113:90-95.
5. Nolan JP, Neumar RW, Adrie C, Aibiki M, Berg RA, Böttiger BW, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A Scientific Statement from the International Liaison Committee on Resuscitation; the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; the Council on Stroke. Resuscitation. 2008 Dec;79(3):350-79.

6. Neumar RW, Nolan JP, Adrie C, Aibiki M, Berg RA, Böttiger BW, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation (American Heart Association, Australian and New Zealand Council on Resuscitation, European Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Asia, and the Resuscitation Council of Southern Africa); the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; and the Stroke Council. Circulation. 2008 Dec 2;118(23):2452-83.
7. Kim YM, Lee SJ, Jo SJ, Park KN. Implementation of the guidelines for targeted temperature management after cardiac arrest: a longitudinal qualitative study of barriers and facilitators perceived by hospital resuscitation champions. BMJ Open. 2016 Jan 5;6(1):e009261.
8. Storm C, Nee J, Krueger A, Schefold JC, Hasper D. 2-year survival of patients undergoing mild hypothermia treatment after ventricular fibrillation cardiac arrest is significantly improved compared to historical controls. Scand J Trauma Resusc Emerg Med. 2010 Jan 8;18:2.
9. Nolan JP, Sandroni C, Böttiger BW, Cariou A, Cronberg T, Friberg H, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2021: Post-resuscitation care. Resuscitation. 2021 Apr;161:220-269.
10. Lemkes JS, Janssens GN, van der Hoeven NW, Jewbali LSD, Dubois EA, Meuwissen M, et al. Coronary Angiography after Cardiac Arrest without ST-Segment Elevation. N Engl J Med. 2019 Apr 11;380(15):1397-1407.
11. Hinson HE, Rowell S, Schreiber M. Clinical evidence of inflammation driving secondary brain injury: a systematic review. J Trauma Acute Care Surg. 2015 Jan;78(1):184-91.
12. Brown GC, Neher JJ. Inflammatory neurodegeneration and mechanisms of microglial killing of neurons. Mol Neurobiol. 2010 Jun;41(2-3):242-7.
13. Emsley HC, Smith CJ, Tyrrell PJ, Hopkins SJ. Inflammation in acute ischemic stroke and its relevance to stroke critical care. Neurocrit Care. 2008;9(1):125-38.
14. Winters SA, Wolf KH, Kettinger SA, Seif EK, Jones JS, Bacon-Baguley T. Assessment of risk factors for post-rewarming “rebound hyperthermia” in cardiac arrest patients undergoing therapeutic hypothermia. Resuscitation. 2013 Sep;84(9):1245-9.
15. Scaravilli V, Tinchero G, Citerio G; Participants in the International Multi-Disciplinary Consensus Conference on the Critical Care Management of Subarachnoid Hemorrhage. Fever management in SAH. Neurocrit Care. 2011 Sep;15(2):287-94.
16. Suffoletto B, Peberdy MA, van der Hoek T, Callaway C. Body temperature changes are associated with outcomes following in-hospital cardiac arrest and return of spontaneous circulation. Resuscitation. 2009 Dec;80(12):1365-70.
17. Launey Y, Nesseler N, Mallédant Y, Seguin P. Clinical review: fever in septic ICU patients--friend or foe? Crit Care. 2011;15(3):222.

18. Cocchi MN, Boone MD, Giberson B, Giberson T, Farrell E, Salciccioli JD, et al. Fever after rewarming: incidence of pyrexia in postcardiac arrest patients who have undergone mild therapeutic hypothermia. J Intensive Care Med. 2014 Nov-Dec;29(6):365-9.

19. Kilpatrick MM, Lowry DW, Firlik AD, Yonas H, Marion DW. Hyperthermia in the neurosurgical intensive care unit. Neurosurgery. 2000 Oct;47(4):850-5; discussion 855-6.

20. Lee BH, Inui D, Suh GY, Kim JY, Kwon JY, Park J, et al. Fever and Antipyretic in Critically ill patients Evaluation (FACE) Study Group. Association of body temperature and antipyretic treatments with mortality of critically ill patients with and without sepsis: multi-centered prospective observational study. Crit Care. 2012 Feb 28;16(1):R33.

21. Stub D, Schmicker RH, Anderson ML, Callaway CW, Daya MR, Sayre MR, et al; ROC Investigators. Association between hospital post-resuscitative performance and clinical outcomes after out-of-hospital cardiac arrest. Resuscitation. 2015 Jul;92:45-52.

22. Reith J, Jørgensen HS, Pedersen PM, Nakayama H, Raaschou HO, Jeppesen LL, et al. Body temperature in acute stroke: relation to stroke severity, infarct size, mortality, and outcome. Lancet. 1996 Feb 17;347(8999):422-5.

23. Honig A, Michael S, Eliahou R, Leker RR. Central fever in patients with spontaneous intracerebral hemorrhage: predicting factors and impact on outcome. BMC Neurol. 2015 Feb 4;15:6.

24. Aujla GS, Nattanmai P, Premkumar K, Newey CR. Comparison of Two Surface Cooling Devices for Temperature Management in a Neurocritical Care Unit. Ther Hypothermia Temp Manag. 2017 Sep;7(3):147-151.

25. Dewilde S, Annemans L, Peeters A, Hemelsoet D, Vandermeeren Y, Desfontaines P, et al. Modified Rankin scale as a determinant of direct medical costs after stroke. Int J Stroke. 2017 Jun;12(4):392-400.

26. Panchal AR, Berg KM, Hirsch KG, Kudenchuk PJ, Del Rios M, Cabañas JG, et al. 2019 American Heart Association Focused Update on Advanced Cardiovascular Life Support: Use of Advanced Airways, Vasopressors, and Extracorporeal Cardiopulmonary Resuscitation During Cardiac Arrest: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2019 Dec 10;140(24):e881-e894.

27. Olasveengen TM, de Caen AR, Mancini ME, Maconochie IK, Aickin R, Atkins DL, et al; ILCOR Collaborators. 2017 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. Circulation. 2017 Dec 5;136(23):e424-e440.

28. Soar J, Donnino MW, Maconochie I, Aickin R, Atkins DL, Andersen LW, et al; ILCOR Collaborators. 2018 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. Circulation. 2018 Dec 4;138(23):e714-e730.

29. Howes D, Gray SH, Brooks SC, Boyd JG, Djogovic D, Golan E, et al. Canadian Guidelines for the use of targeted temperature management (therapeutic hypothermia) after cardiac arrest: A joint statement from The Canadian Critical Care Society (CCCS), Canadian Neurocritical Care Society (CNCCS), and the Canadian Critical Care Trials Group (CCCTG). Resuscitation. 2016 Jan;98:48-63.

30. Holzer M, Bernard SA, Hachimi-Idrissi S, Roine RO, Sterz F, Müllner M; Collaborative Group on Induced Hypothermia for Neuroprotection After Cardiac Arrest. Hypothermia for neuroprotection after cardiac arrest: systematic review and individual patient data meta-analysis. Crit Care Med. 2005 Feb;33(2):414-8.

31. Arrich J, Holzer M, Herkner H, Müllner M. Hypothermia for neuroprotection in adults after cardiopulmonary resuscitation. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD004128.

32. Cullen D, Augenstine D, Kaper L, Tinkham S, Utz D. Therapeutic hypothermia initiated in the pre-hospital setting: a meta-analysis. Adv Emerg Nurs J. 2011 Oct-Dec;33(4):314-21.

33. Cheung KW, Green RS, Magee KD. Systematic review of randomized controlled trials of therapeutic hypothermia as a neuroprotectant in post cardiac arrest patients. CJEM. 2006 Sep;8(5):329-37.

34. Merchant RM, Becker LB, Abella BS, Asch DA, Groeneveld PW. Cost-effectiveness of therapeutic hypothermia after cardiac arrest. Circ Cardiovasc Qual Outcomes. 2009 Sep;2(5):421-8.

35. Nolan J, Soar J, Böttiger B. ERC Statement on targeted temperature management. Therapeutic hypothermia following cardiac arrest: recent studies on targeted temperature. Disponible en: http://www.endurlifgun.is/static/files/statement-on-targeted-temperature-management.pdf. Acceso: marzo 2021.

36. Ferrer Roca R, Sánchez Salado JC, Chico Fernández M, García Acuña JM, Lesmes Serrano A, López de Sá E, et al. Management of temperature control in post-cardiac arrest care: an expert report. Med Intensiva. 2020 Jul 20:S0210-5691(20)30213-8.

37. Perkins GD, Olasveengen TM, Maconochie I, Soar J, Wyllie J, Greif R, et al; European Resuscitation Council. European Resuscitation Council Guidelines for Resuscitation: 2017 update. Resuscitation. 2018 Feb;123:43-50.

38. Fernández Lozano I, Urkía C, Lopez Mesa JB, Escudier JM, Manrique I, de Lucas García N, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Key Points. Rev Esp Cardiol (Engl Ed). 2016 Jun;69(6):588-94.

39. Yeh YC, Reddy P. Clinical and economic evidence for intravenous acetaminophen. Pharmacotherapy. 2012 Jun;32(6):559-79.

40. Peacock WF, Breitmeyer JB, Pan C, Smith WB, Royal MA. A randomized study of the efficacy and safety of intravenous acetaminophen compared to oral acetaminophen for the treatment of fever. Acad Emerg Med. 2011 Apr;18(4):360-6.

41. Dippel DW, van Breda EJ, van der Worp HB, van Gemert HM, Meijer RJ, Kappelle LJ, et al; PISA-Investigators. Effect of paracetamol (acetaminophen) and ibuprofen on body temperature in acute ischemic stroke PISA, a phase II double-blind, randomized, placebo-controlled trial [ISRCTN98608690]. BMC Cardiovasc Disord. 2003 Feb 6;3:2.

42. Gillies MA, Pratt R, Whiteley C, Borg J, Beale RJ, Tibby SM. Therapeutic hypothermia after cardiac arrest: a retrospective comparison of surface and endovascular cooling techniques. Resuscitation. 2010 Sep;81(9):1117-22.

43. Oh SH, Oh JS, Kim YM, Park KN, Choi SP, Kim GW, et al; Korean Hypothermia Network Investigators. An observational study of surface versus endovascular cooling techniques in cardiac arrest patients: a propensity-matched analysis. Crit Care. 2015 Mar 16;19(1):85.

44. Flemming K, Simonis G, Ziegs E, Diewok C, Gildemeister R, Wunderlich C, Strasser RH. Comparison of external and intravascular cooling to induce hypothermia in patients after CPR. Ger Med Sci. 2006 Jun 8;4:Doc04.

45. Vaity C, Al-Subaie N, Cecconi M. Cooling techniques for targeted temperature management post-cardiac arrest. Crit Care. 2015 Mar 16;19(1):103.

46. Amey C. Tailored Temperature Management in Neurocritcial Care. European Neurological Review, 2016;11(Suppl. 1):2–4.

47. Mayer SA, Kowalski RG, Presciutti M, Ostapkovich ND, McGann E, Fitzsimmons BF, et al. Clinical trial of a novel surface cooling system for fever control in neurocritical care patients. Crit Care Med. 2004 Dec;32(12):2508-15.

48. Hoedemaekers CW, Ezzahti M, Gerritsen A, van der Hoeven JG. Comparison of cooling methods to induce and maintain normo- and hypothermia in intensive care unit patients: a prospective intervention study. Crit Care. 2007;11(4):R91.

49. Rinehart J, Lilot M, Lee C, Joosten A, Huynh T, Canales C, et al. Closed-loop assisted versus manual goal-directed fluid therapy during high-risk abdominal surgery: a case-control study with propensity matching. Crit Care. 2015 Mar 19;19(1):94.

50. Madden LK, Hill M, May TL, Human T, Guanci MM, Jacobi J, et al. The Implementation of Targeted Temperature Management: An Evidence-Based Guideline from the Neurocritical Care Society. Neurocrit Care. 2017 Dec;27(3):468-487.

51. Sunde K. Therapeutic hypothermia in cardiac arrest. Rev Esp Cardiol (Engl Ed). 2013 May;66(5):346-9.

52. Michels G, Wengenmayer T, Hagl C, Dohmen C, Böttiger BW, Bauersachs J, et al. Recommendations for extracorporeal cardiopulmonary resuscitation (eCPR): consensus statement of DGIIN, DGK, DGTHG, DGfK, DGNI, DGAI, DIVI and GRC. Clin Res Cardiol. 2019 May;108(5):455-464.

53. Moseby-Knappe M, Westhall E, Backman S, Mattsson-Carlgren N, Dragancea I, Lybeck A, et al. Performance of a guideline-recommended algorithm for prognostication of poor neurological outcome after cardiac arrest. Intensive Care Med. 2020 Oct;46(10):1852-1862.

54. Walker AC, Johnson NJ. Targeted Temperature Management and Postcardiac arrest Care. Emerg Med Clin North Am. 2019 Aug;37(3):381-393.

55. Ponz I, Lopez-de-Sa E, Armada E, Caro J, Blazquez Z, Rosillo S, et al. Influence of the temperature on the moment of awakening in patients treated with therapeutic hypothermia after cardiac arrest. Resuscitation. 2016 Jun;103:32-36.

56. Lybeck A, Cronberg T, Aneman A, Hassager C, Horn J, Hovdenes J, et al. Time to awakening after cardiac arrest and the association with target temperature management. Resuscitation. 2018 May;126:166-171.

57. Dragancea I, Wise MP, Al-Subaie N, Cranshaw J, Friberg H, Glover G, et al. Protocol-driven neurological prognostication and withdrawal of life-sustaining therapy after cardiac arrest and targeted temperature management. Resuscitation. 2017 Aug;117:50-57.

58. Scholz KH, Andresen D, Böttiger BW, Busch HJ, Fischer M, Frey N, et al. Qualitätsindikatoren und strukturelle Voraussetzungen für Cardiac-Arrest-Zentren – Deutscher Rat für Wiederbelebung/German Resuscitation Council (GRC) [Quality indicators and structural requirements for Cardiac Arrest Centers-German Resuscitation Council (GRC)]. Anaesthesist. 2017 May;66(5):360-362.

59. Alfieri E, Mori M, Barbui V, Sarli L. Advanced competencies mapping of critical care nursing: a qualitative research in two Intensive Care Units. Acta Biomed. 2017 Jul 18;88(3S):67-74.

60. Ministerio de Sanidad y política social. Unidad de cuidados intensivos. Estándares y recomendaciones. Informes, estudios e investigación, 2010. Disponible en: https://www.mscbs.gob.es/organizacion/sns/planCalidadSNS/docs/UCI.pdf. Acceso: marzo 2021.

61. Scholz KH, Böttiger BW. Cardiac-Arrest-Zentren. Notfall Rettungsmed 2017:20:232–233.

Chapter 3.2
STUDY OF COSTS RELATED TO OUT-OF-HOSPITAL CARDIAC ARREST IN SPAIN

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Summary

General objective

To analyse the **economic burden of cardiac arrest in Spain** and its **cost-effectiveness** in relation to the measures recommended by the European Resuscitation Council (ERC) based on data from the survey conducted in the CAPAC project (2020). Data from 109 of the 115 Spanish hospitals that participated in the survey were used in this analysis. Based on the analysis, the conclusions have been extrapolated at national level to estimate the costs of cardiac arrest and the cost savings of the measures recommended by the ERC.

Methods

To calculate cardiac arrest costs at patient and hospital level, data were used from the public prices updated in 2020 and, to calculate this at national level, national and autonomous community incidence data from the OHSCAR study were used[1,2].

Resultados principales

The analysis began with which **techniques included in the ERC recommendations** and in the **survey** carried out of the 109 hospitals have a significant statistical effect on the patient's final neurological state (out of 115). The hospitals included in the study generate estimated annual costs related to cardiac arrest of approximately 84 million euros. Nearly half of these costs are of a non-healthcare nature. The average and total costs are higher in unfavourable neurological states. A **fractional econometric model** was used, the result of which points to the critical role played by the use of servo-control in the proportion of patients in the different neurological states upon patient discharge. In a simulated scenario, compatible with the results of the population analysed, differentiated treatment in temperature control management (TTM) with or without servo-control instruments results in a saving over the total sample of approximately 2.36 million euros (an average saving of 1,452 euros per patient treated) and a 2.85% saving over TTM with alternative techniques. The estimate of the total costs at national level of the population suffering a cardiac arrest in 2020 would total 154 million euros throughout the expected life of this population. This would generate a potential financial saving of 40 million euros if servo-control techniques are used rather than alternative techniques, a saving that comes from only one generation of patients suffering a cardiac arrest, in other words, patients from the year 2020. From a cost effectiveness perspective related to the use of temperature control techniques, the cost effectiveness ratio (referring to direct costs) generates a figure 10 times lower than the reference thresholds of the British National Institute for Health and Care Excellence (NICE) in its recommendations, thus indicating that this technique is cost-effective and it should be accepted for implementation.

1. Introduction

This section analyses the **impact of the different post resuscitation care recommendations** established by the ERC with regards to both the percentage of patients according to their neurological level when discharged from the hospital, as well as the different costs associated with each patient, depending on their neurological state upon discharge.

This analysis is based on the results of a survey with a sample of 115 hospitals in Spain aimed at finding out the variability in the treatment of patients after cardiac arrest: clinical practices, structures and processes in patient treatment (see results in Annex 3). The survey makes it possible to analyse the variability or adherence by participating hospitals to the recommendations set out by the ERC3: 1. Early initiation of effective CPR; 2. Constant temperature control post-PCI, a target fixed temperature of 36°C or a range between 32-36°C as soon as possible during more than 24 hours, increasing the temperature between 0.25-0.5°C per hour during rewarming; 3. Evaluation of the neurological prognosis and decision regarding treatment no earlier than 72 hours after ROSC; 4 Systematic organisation, which should include the assessment of any potential cognitive and emotional alterations and the provision of information.

Using the responses received in the survey, it has been possible to identify which recommendations have a significant effect on improving the neurological state of patients, and those which do not, thus allowing clinical progress in improving hospital practices implemented for the care of cardiac arrest patients.

The **CPC classification** has been used for this analysis (see chapter 2. Conceptual framework). In parallel, we will measure the savings in costs and cost effectiveness of the technique or process that is most advantageous for the patient's health, compared to a situation in which it is not applied. Given the impossibility of carrying out a counter-factual study that could gauge the impact of the different measures in a clear manner, and given the type of data available, which is aggregate and not individual, all the analyses presented in this report will have this intrinsic limitation. Lastly, an **estimate of the annual cost of cardiac arrest to Spanish society** will be provided.

2. Framework for analysis

The analyses presented in the following sections have been based on the responses received from 109 hospitals*. The responses received from the hospitals refer to a population of 2,631 patients treated for out-of-hospital cardiac arrest, of which 1,001 (38.05%) did not survive, whereas 1,630 (61.95%) did survive, with different neurological conditions upon discharge**. Specifically, 719 patients (44.11%) were discharged from hospital with a very favourable neurological condition (CPC1), 407 (24.97%) with a favourable neurological condition (CPC2), 276 (16.93%) with an unfavourable neurological condition (CPC3) and 228 (13.99%) with a very unfavourable condition (CPC4). These average percentages reported by the hospital show a substantial improvement in relation to those provided by the Ministry of Health taken from the Out-of-Hospital Spanish Cardiac Arrest Registry (OHSCAR project) in which the reported survival totals only 38.1% compared to 61.95% reported in the survey of this study.

One way of interpreting the survey which acts as a basis for the study of out-of-hospital cardiac arrest costs, presented in the following section, is to **identify structures and/or clinical action protocols and associate them with the total costs**, as well as the survival and the neurological state of the patients.

To carry out these analyses (neurological states and cardiac arrest costs) we will use a multivariate **regression model** in which we will have previously identified (selected) questions from the survey (variables) which may later have an impact (positive or negative) on the neurological states of the patients and on the cost structure. These variables are grouped into three blocks: 1. Protocol block relating to the coronarography and percutaneous coronary intervention (PCI); 2. Therapeutic temperature management (TTM) block; and 3. Prognosis and rehabilitation block. These three main blocks contain the recommendations issued by the ERC. With this in mind, the following variables relating to the questions on the survey have been considered. These are presented in Table 2.1 showing the selected questionnaire questions and the type of variable.

Table 2.1. Explanatory variables used in the analyses

Variable	Survey question	Type of variable
PCI block		
Coronarography and PCI	5	Binary (1/0)
Time objective for PCI	7(b)	Binary (1/0)
PCI execution time	8	Discrete (1-6)
PCI availability	11	Binary (1/0)
TTM block		
TTM Active Control	17	Binary (1/0)
Time objective for commencement of TTM	20	Binary (1/0)
Servo-control use	21	Binary (1/0)
Thermal recovery	22	Binary (1/0)
Aim is to reach a temperature	24	Binary (1/0)
Prognosis and rehabilitation block		
Use of prognostic scales 72 hours	25	Binary (1/0)
Long-term monitoring	30	Binary (1/0)
Rehabilitation programme	31	Binary (1/0)

**The remaining 6 hospitals that responded to the survey did not respond to question 32 of the questionnaire, concerning the percentage of patients who end up in each of the neurological stages (CPC1, CPC2, CPC3, CPC4 and CPC5, see footnote 2), hence they cannot be considered for the analysis of the final condition of the patients and the costs associated with each of the patients.*

***The neurological states are listed in the appendix of this study under the acronyms relating to CPC.*

Below we show which variables shown in the above table are measured and how they are measured

- **Coronarography and PCI:** takes a value of 1 if all patients undergo coronary angiography and PCI and 0 in all other cases.
- **Time objective for PCI:** A value of 1 is given if the procedure anticipates a time objective for performing the PCI and it is normally measured, and a 0 if otherwise.
- **PCI execution time:** Average time in which PCI is performed. Pre-coded into one hour periods in the survey. A value of 1 is given if the average time during which PCI is performed is 60 minutes, 2 if it is 120 minutes, 3 if it is 180 minutes, 4 if it is 240 minutes, 5 if it is 300 minutes and 6 if it is 360 minutes.
- **PCI availability:** a value of 1 is given if there is a 24 hour PCI service, and a 0 for all other options of the reference question.
- **TTM Active Control:** A value of 1 is given if the temperature is controlled actively and a 0 if it is not.
- **Time objective for commencement of TTM:** A value of 1 is given if there is a TTM commencement objective and 0 if there is not.
- **Servo-control use:** A value of 1 is given if the temperature control is performed through catheters/hydrogel patches with advanced servo-control devices, and a 0 if the control is carried out by any other of the alternative methods provided in the survey.
- **Thermal recovery:** A value of 1 is given if there is a recovery of the temperature after the TTM and 0 if there is not.
- **The aim is to reach a temperature:** A value of 1 is given if there is a target temperature and 0 if there is not.
- **Use of 72-hour prognostic scales:** A value of 1 is given if prognosis scales are applied during the first 72 hours and a 0 if they are not.
- **Long-term monitoring:** A value of 1 is given if the patients are monitored in the long term and a 0 if they are not.
- **Rehabilitation programme:** A value of 1 is given if there is a rehabilitation protocol and 0 if there is not.

3. Explanatory factors of the neurological states of the patients when discharged from hospital

The techniques or procedures used from the time of admission of a patient presenting cardiac arrest until their discharge are not applied independently. From a quality-of-life perspective of the treated patient, for example, not only does the execution time of a PCI necessarily explain the final neurological state of the patient, but that said procedure is carried out simultaneously with others, such as, for example, the technique used for temperature control. In order to have a **more panoramic view**, and given the limitations inherent in the type of data with which this study is conducted, we have designed and estimated a **fractional multinomial model**[4] that allows us to see the effects of the variables discussed in the previous section on the different neurological states considered in this work. A more direct interpretation of the effects of the explanatory variables concerning our variable of interest (percentage of patients in the different neurological states), Table 3.1 presents the marginal effects of the estimation of the model.

From a quality-of-life perspective and, as we will see, also the cost, it is interesting to **differentiate between the favourable neurological states (CPC1 and CPC2) and the unfavourable states (CPC3 and CPC4)**. The second column of Table 3.1 details the effects that the different explanatory variables have on the proportion of patients with unfavourable states compared to those with favourable states. It is noteworthy that the only explanatory variable that has a significant and sizeable effect on the variation in the proportion of patients in the different stages is the use or non-use of temperature control by servo-based techniques. In particular, the results indicate that the use of servo-control results in a 12.8% decrease in patients with a final unfavourable state compared to more favourable states. This estimation discounts or controls the effects that other procedures or techniques used during the patient's stay at the hospital, and included in the analysis, could have on the proportion of patients in different states. Furthermore, it should be noted that the impact of these other variables is not statistically significant for the purposes of the analysis carried out using the multinomial model; only long-term monitoring seems to have a very small effect on reducing patients with unfavourable states.

Within this analysis framework, and in relation to the change from favourable neurological states to unfavourable (or viceversa), it seems reasonable to consider a greater likelihood of changing from state CPC3 to CPC2 than from CPC4 to CPC2 or CPC1. The fourth column in Table 3.1 presents the marginal effects of the explanatory variables on the proportion of patients in states CPC2 and CPC3. Using state CPC2 as a basis for comparison we can corroborate that, as before, only the use of the servo-control generates a decrease in the percentage of patients with state CPC3. In particular, the application of this temperature control technique would reduce patients in state CPC3 by 9.8% compared to the proportion of patients in neurological state CPC2.

The table 3.1 shows the marginal effects of a fractional multinomial model.

Variables	Unfavourable CPCs vs Favourable CPCs	CPC3 vs CPC2
Coronarography and PCI	0.078	-0.019
	[0.064]	[0.039]
Time objective for PCI	-0.032	0.006
	[0.067]	[0.051]
PCI execution time	-0.003	-0.000
	[0.000]	[0.000]
TTM Active Control	-0.130	-0.151
	[0.119]	[0.120]
Time objective for commencement of TTM	0.039	-0.021
	[0.060]	[0.039]
Servo-control use	**-0.128** **	**-0.098** **
	[0.064]	[0.043]
Thermal recovery	0.039	0.011
	[0.080]	[0.061]
Aim is to reach a temperatura	-0.058	-0.039
	[0.086]	[0.080]
Use of prognostic scales 72 hours	-0.090	-0.036
	[0.056]	[0.038]
Long-term monitoring	**-0.094** *	-0.031
	[0.056]	[0.038]
Rehabilitation programme	-0.005	0.012
	[0.060]	[0.041]
Observations	**79**	**79**

Table 3.1. Analysis of the effects of the different protocols and techniques on the percentage of patients by neurological state

***, * represents the significance of the marked variable at 5% and 10%, respectively. Cluster at hospital level.*

4. Study and analysis of cardiac arrest costs

4.1. Descriptive analysis of the annual cost per patient and hospital

This part of the report will look at **the annual cost of cardiac arrest at patient and hospital level**, valued in 2020 euros*. For this calculation (see methodological appendix in Annex 4), we have used the data reported by the hospitals in the survey for this study.

It is observed that, on average, the non-health costs per patient account for about 55% of the total average cost per cardiac arrest patient. This is ten percentage points higher than the average healthcare costs per patient. Among the latter, we can observe that the costs associated with ICU, stay and rehabilitation account for a greater share of direct healthcare costs, with prognostic costs representing the lowest burden on the system.

Table 4.1. Average healthcare and non-healthcare costs per patient admitted alive		
Average costs per patient	Euros 2020	Percentage
Average ICU costs	11,001	15.0%
Average costs of stay	8,906	12.1%
Average prognostic costs	210	0.3%
Average rehabilitation costs	10,878	14.8%
Average TTM costs	2,518	3.5%
Average indirect costs (non-healthcare)	**39,989**	**54.4%**

The component relating to the neurological state upon discharge of the patient is of singular importance for this analysis, once again indicated using the acronym CPC**. As previously mentioned, the neurological states can be: Very favourable CPC1, favourable CPC2, unfavourable CPC3 and very unfavourable CPC4. The most favourable neurological states have lower non-healthcare costs, given the relative value of the indirect cost in the total average cost. They also represent a lower burden in terms of healthcare costs, given the need for a lower rehabilitation time. It is therefore useful to know the **cost structure by level of neurological condition**.

**All costs have been updated using the variation in the consumer price index published by the Spanish National Statistics Institute for the year of publication or reference for the prices used herein.*

***The cost analysis presented in this report is based on the costs incurred by patients who manage to survive and therefore the costs associated with CPC5 patients are not included. Furthermore, as we do not have individual data, we cannot identify when these patients die and therefore which costs, derived from the different protocols, have to be attributed to them. In any case, they do not generate any future cost, unlike patients in other neurological states.*

Table 4.2 details the total average annual cost by patient and neurological state. As we expected, as the neurological state worsens, the total average cost per patient increases very significantly. The CPC1 case is indicative of a patient who, after out-of-hospital cardiac arrest, has a condition at discharge that requires no rehabilitation costs, given their neurological recovery. The costs associated with CPC2, CPC3 and CPC4 states are approximately 85%, 150%, 250% higher than those of a patient with a CPC1 state. In other words, unfavourable neurological states increase the average cost per patient by between 1.5 and 2.5 times, compared to a patient with the best possible condition.

Table 4.2. Total average costs per patient depending on neurological state upon discharge

Average costs per patient	Euros 2020
CPC1	28,332.7
CPC2	52,950.3
CPC3	71,207.9
CPC4	97,953.1

The admissions of patients suffering cardiac arrest are distributed differently among the various hospitals from the sample. From the point of view of the costs assumed by the hospitals, we can observe in **Table 4.3** that the average total hospital costs amounted to 464,881 euros in 2020. Of this amount, 33% refers to ICU costs, 30% to rehabilitation costs and 28% to hospital stay costs. Temperature management and control (TTM) accounted for an average of 7.2%*. If we also consider the indirect costs, the total average cost per hospital would increase to 768,474 euros, which would give rise to a total annual cost for all 109 hospitals of around 84 million euros/year**.

Table 4.3. Average costs per hospital (healthcare and non-healthcare)

Average hospital and social cost	Euros 2020	% of average hospital cost	% of average total cost
Average hospital ICU costs	155,324	33,4%	
Average hospital stay costs	131,975	28,4%	
Average hospital prognostic costs	2,975	0,6%	
Average hospital rehabilitation costs	141,026	30,3%	
Average hospital TTM costs	33,581	7,2%	
Average total hospital costs	464,881	100%	60,5%
Average indirect costs (non-healthcare)	303,592		39,5%
Average total hospital and social costs	768,474		100%

**For the calculation of the average costs per hospital, the same procedure was followed as described for the average calculation per patient (see methodological appendix), but the average was derived using the average admissions (average number of patients admitted with cardiac arrest) of the 109 hospitals.*

***The reader is informed that the data reported refers to average costs, and, therefore, there will be hospitals whose real annual cost is lower and others whose annual cost is higher. These annual costs per hospital will depend on the protocols used for each one of the hospitals and the number of annual admissiins of said centre.*

4.2. Multivariate model of factors associated with the total cost of cardiac arrest

As we have already done in the analysis of the factors that affect the final neurological state of the patients, in this part of the report we are also going to identify those structures and/or clinical action protocols and associate them with the total costs borne by the system.

The **results of the resulting multi-variant5 linear regression model**[5] are shown in **Table 4.4.** Generally speaking, the model can statistically explain the variation in the total variable costs that a cardiac arrest in those patients that survive represents, and is able to explain around 32% of the variation.

In this association model it can be seen that the block that has a significant effect on the variation in total costs is mainly that relating to therapeutic temperature management. This is also true for the prognosis and rehabilitation block but to a lesser extent. It is noteworthy that the block of procedures related to PCI practice is not statistically relevant in explaining the costs related to cardiac arrest. However, the availability of PCI is very close to being cost relevant.

With regard to TTM, it is observed that the use of temperature controls using servo-control devices is associated with a higher total cost, which is to be expected. It is estimated that the use of the servo-control technique increases the average cost by 472,142.90 euros, compared to the use of other TTM techniques. The same happens, but with a somewhat lower statistical relevance, to the variable indicating the existence of a time objective for the commencement of temperature control, which increases the total cost by 318,971.50 euros. All indications are that if there is a target for the start of temperature control, this has a negative impact on the hospital's costs, which at first sight seems counter-intuitive. It is also particularly interesting that when the hospital protocols anticipate a target temperature, and after discounting the effect of the other temperature control variables, the costs decrease significantly. Specifically, the estimate indicates that the cost would be reduced by -601,655.5 euros for those hospitals that have an established target temperature compared to those without such a protocol. The analysis suggests that both having an initial temperature control objective and using servo-control techniques significantly increase the costs borne by hospitals. However, these can be reduced if there is a declared and protocolised target level. If we look at the relationship of variables associated with TTM, we can see that although the "TTM active control" variable is not statistically significant, its sign, in other words, its relationship with the cost goes in the same direction as the "Temperature objective" variable, which reinforces the idea expressed earlier. In the following section we will have a closer look at the relationship between the use of TTM and the final neurological states of the patients, which as we have already explained have different associated costs.

The results referring to the block that details the rehabilitation protocols suggests, on the one hand, that if the protocol provides for a rehabilitation programme, whether locomotive, neuro-rehabilitative or occupational therapy, the effect on the cost is positive and is very close to a significance of 10%. Whereas on the other hand, it indicates that if there is a treatment or follow-up of patients once discharged from the hospital, the costs also increase (€358,509) with a significance very close to 5%. Both considerations indicate the need for a more detailed study into these aspects.

Table 4.4. Linear regression model for costs		
Total cost on discharge	Average change in the cost	
Coronarography and PCI	13,416.89	
	(248,573.3)	
Time objective for PCI	-377,917.5	
	(260,291.2)	
PCI execution time	-195.45	
	(1,299.91)	
PCI availability	349,565.1	+
	(229,044)	
TTM Active Control	-74,791.85	
	(253,659.1)	
Time objective for commencement of TTM	318,971.5	*
	(173,295.1)	
Servo-control use	**472,142.9**	**
	(214,574.3)	
Thermal recovery	64,263.53	
	(171,226.1)	
Aim is to reach a temperatura	**-601,655.5**	**
	(287,616.1)	
Use of prognostic scales 72 hours	97,538.44	
	(190,784.7)	
Long-term monitoring	358,509	*
	(186,331.1)	
Rehabilitation programme	262,133.8	+
	(165,354.3)	
Constant	**772,754.5** (387,997.8)	**
R-squared	**0.3173**	
Observations	**79**	

***, * represents the significance of the marked variable at 5% and 10%, respectively*

+ indicates that it is very close to the statistical relevance. Cluster at hospital level. The coefficients with the + sign indicate a higher cost and the coefficients with the - sign, a lower cost.

4.3. Descriptive analysis of the impact of the use of servo-control on the final states of the patients

In Table 3.1 we observed that, of the different procedures and techniques used on a patient presenting a cardiac arrest, **only the use of servo-control techniques seem to reduce the number of patients with an unfavourable state**. It should be remembered that these states are unfavourable in terms of health but also in terms of costs. In the previous section we also observed the significant impact of the use of TTM techniques on the total average cost. Both results head in opposite directions, therefore we need to analyse which of the two effects is predominant.

In this section we will present descriptive data for the 109 hospitals in relation to the proportion of patients upon discharge divided by neurological status. These data are presented according to the TTM technique followed by the hospital. Specifically, we are going to differentiate between those hospitals that follow a temperature control protocol based on servo-control mechanisms (SVC) and those that follow other protocols to achieve hypothermia in the patient*. In the rest of this section, the CPC5 state is discarded for the analysis, since it is understood that the patient who ends up in CPC5 does so regardless of the temperature control mechanism used**.

In order to carry out a more in-depth analysis of the effect of servo-control on the number of patients dying in hospital, we would need to have individualised data to identify whether the patient who died had time to receive and whether they were given any type of TTM. Of those for whom some form of temperature control was applied, we would have to study whether the different TTM techniques have a different effect in reducing the percentage of deaths.

Table 4.5 shows the percentage of patients by condition, specifying whether or not the hospital in which they were treated follows a servo-control mechanism.

Table 4.5: Percentage of patients by CPC (hospitals that report CPC and follow some temperature control protocol)

	Low-cost states		High-cost states	
	CPC1	CPC2	CPC3	CPC4
No servo-control	26.31	14.61	15.24	9.49
With servo-control	25.59	16.78	9.97	8.33

**Many of the hospitals surveyed indicate they follow several action protocols to reduce patient temperature. In some cases they indicate that they use servo-control mechanisms as well as other temperature control mechanisms. This, together with not having data at patient level, prevents us from identifying the servo-control effect on the final state of the patient. Therefore, all the data presented in this section will be an approximation of the effect to be analysed. Specifically, the hospital shall be deemed to use the servo-control system if it so indicates, irrespective of whether it also uses other mechanisms.*

***The percentage of patients that die in hospitals that apply servo-control techniques totals 39.32% compared to 34.34% of patients that die in hospitals where no servo-control is applied. These percentages are not statistically significant using either the Wilcoxon rank-sum (Mann-Whitney) test or the two-tailed equal variance t-test.*

The data indicate that controlling the temperature through the use of SVC can be beneficial to patient health. If we observe the percentages reported in Table 4.5, we can verify that the proportion of patients that have been treated using techniques other than servo-control and who end up with unfavourable neurological states (CPC3 and CPC4) is higher (15.24% and 9.49%) than that recorded when SVC has been applied (9.97% and 8.33%)*. However, there are no notable differences in favourable states. However, and given that within these percentages we are taking into account large, medium-sized and small hospitals (measured in terms of numbers of beds), in order to make a more accurate comparison, we need to carry out a standardisation depending on the number of patients that have been treated with one temperature control method or another. This standardisation will allow us to have a common scale and, therefore, comparisons can be made between both treatments**.

Table 4.6 shows the standardised ratios, which will be used for the rest of the study. Contrary to that indicated in Table 4.5, after standardisation, we can see that the proportion of patients ending up with an optimum state (CPC1) is 10 percentage points higher in the case of servo-control compared to the use of other temperature control techniques. The opposite happens for more unfavourable states, especially CPC3, where the use of servo-control noticeably reduces the proportion of patients in this state (21.7% compared to 14.3%). These data reinforce the earlier assumptions regarding the benefits of using servo-control in the neurological improvement of patients.

Table 4.6. Standardised ratios

	Low-cost states		High-cost states	
	CPC1	CPC2	CPC3	CPC4
No servo-control	0.379	0.248	0.217	0.156
With servo-control	0.471	0.251	0.143	0.135

**The percentage of patients in CPC3 and CPC4 in hospitals that do not apply SVC is 24.73%, compared to 18.30% in hospitals that do apply SVC. This difference is statistically significant at 5% using a one-tailed equal variance t-test.*

***We standardised on the basis of the number of patients who were treated with SVC and the number of patients for whom SVC was not used.*

4.4 Simulation of the cost that the generalised use of servo-control would represent

Given the importance that the use of servo-control seems to have both for the neurological state of patients as well as the impact on the costs borne by the hospitals, we will now investigate what the **effect is on the average total cost (health and non-health) of widespread use of SVC**.

To do so, we will first take into account the empirical observation already made that hospitals that monitor the temperature by SVC of their patients admitted for cardiac arrest seem to improve their neurological state upon discharge. Secondly, we must take into account that the SVC technique has a higher monetary cost than that of not controlling the temperature or by controlling the temperature using alternative mechanisms. Thirdly, we consider that patients with a favourable neurological state on discharge generate lower average non-healthcare costs, as we previously mentioned.

In order to evaluate these issues, we have generated a **simulated scenario using the data obtained from the survey**. The simulation evaluates the total average annual costs of the entire population (1,630 patients) as if all had been treated using SVC. This would imply that we assume that this population is distributed throughout the four CPC scenarios in similar proportions to those that we have found in the survey (see Section 2) We have done the same with the alternative and exclusionary scenario, i.e. we compare them with the simulated situation of no SVC treatment. Having created this scenario, the cost that the use of the servo-control technique would represent for the 109 hospitals as a whole and the difference in costs if it were not used will be calculated. In this manner, we could measure the possible savings in costs during the year, for society, if this technique became standardised in all hospitals. The results are detailed in Table 4.7.

Table 4.7. Total costs by simulation scenario for the year of the cardiac arrest

State	SVC scenario	No SVC scenario	Difference in costs
CPC1	21,361,246.2	13,695,788.4	7,665,457.8
CPC2	22,245,819.9	21,363,069.1	882,750.9
CPC3	16,712,911.6	25,124,331.5	-8,411,419.9
CPC4	22,516,237.3	25,020,450.2	-2,504,212.8
Total cost	82,836,215.2	85,203,639.1	-2,367,423.9

A + difference in costs means that the servo-control scenario represents a greater total average cost than the no servo-control scenario. A - difference, for example, such as that reported in the total cost line, represents a saving in costs if the servo-control technique is used, in other words, lower costs using SVC compared to no SVC.

We can see that the total savings for society through the use of SVC in this simulated scenario is around 2.36 million euros. This represents an average saving of 1,452 euros per treated patient. In percentage terms, adopting SVC in this simulation scenario represents a saving of 2.85% compared to the alternative of not using SVC treatment. This saving simulation is an annual saving that reflects both healthcare and non-healthcare costs.

4.5. Approximation to a Decision-making Model based on the cost effectiveness of servo-control techniques

The cost effectiveness analysis (CEA) (in general terms, the healthcare technology economic assessment (HTEA) method), is aimed at evaluating the relationship existing between the additional cost involved in incorporating a new technology (procedure, treatment, medication, care process, etc.) and the additional benefit that its use would offer in terms of improving health6.

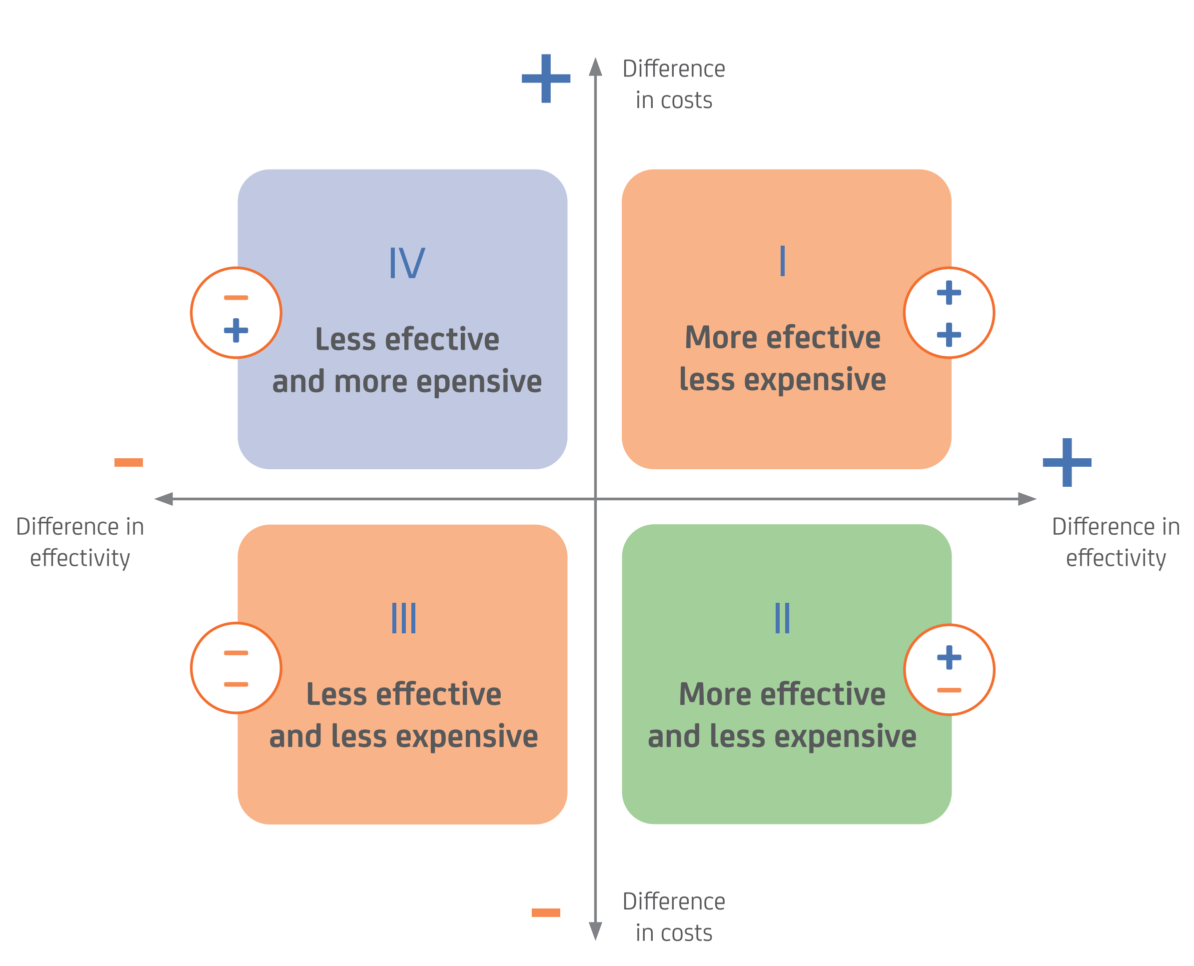
In particular, the CEA measures the benefits/results in non-monetary units (unlike a cost-benefit analysis, which monetises the health benefits), with it being preferable to use final measurements of results, such as years of life gained or the quality-adjusted life years (QALY) gained. This last measurement combines the time of life (survival) and the quality of life into a single value, represented through useful indices based on a scale in which 0 represents death and 1 represents perfect health (for this reason the CEA that uses QALY as a unit for the results is usually known as cost-usefulness analysis).

The HTEA methods, among them the CEA, are thus characterised by measuring and evaluating both the costs as well as the results of the treatments and also by doing so in comparative terms (incremental). The final result of a cost-effectiveness study is the so-called incremental cost-effectiveness ratio, which is obtained by dividing the increase in costs of the technology evaluated against the comparator (normally the status quo), by the gain in effectiveness (in health) provided by the technology:

$$ICER=\Delta C/\Delta E$$

If we represent the cost and effectiveness of a new technology compared to another on a coordinates axis (in other words, we match the origin of coordinates with the comparator), we obtain what is known as the cost-effectiveness plane (Figure 4.1), the most frequent being that the technologies that are evaluated are placed in the upper right quadrant of the plane (higher cost and more effective). Thus, generally, the ICER we will get from benchmarking an intervention will tell us how much more it costs us to gain a unit of health (a QALY, for example) with the new technology compared to the pre-existing one. To find out whether the value of the ICER obtained is reasonable or not, in other words, to be able to evaluate whether the decision to finance this new intervention represents an efficient use of resources, it is necessary to have a reference that allows us to know when a technology is or is not cost-effective. The only environment where there is an explanatory threshold applicable to decision-making is in the United Kingdom, where the National Institute for Health and Care Excellence (NICE) establishes a value of £20,000 for each QALY gained as a threshold under which an ICER can be considered as acceptable. In other countries there are no explicit thresholds, although there are estimates of the monetary value of a QALY based on different methodologies.

Figure 4.1. The cost-effectiveness plane

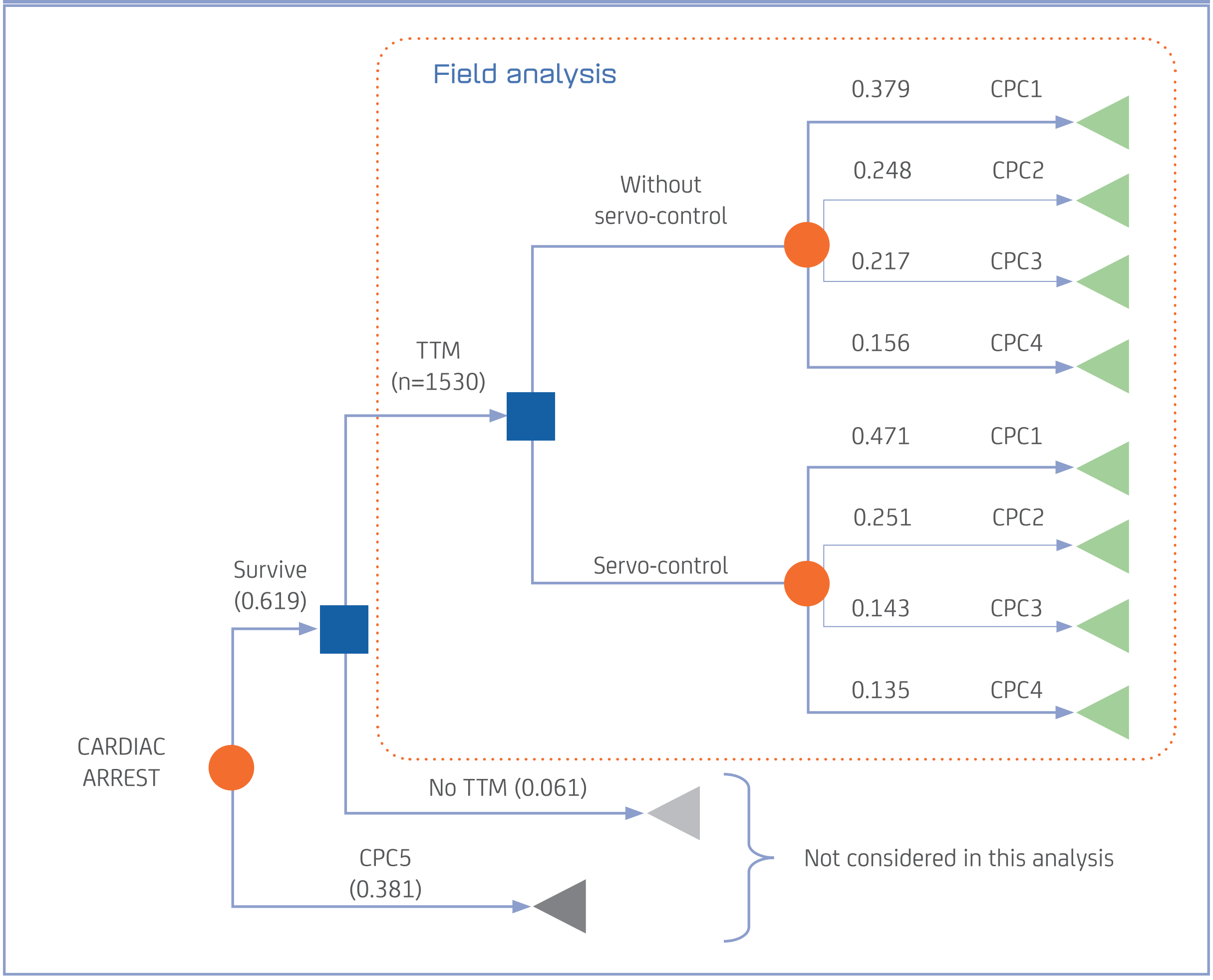


In this section we carry out a **first approximation of the cost-effectiveness of the servo-control procedure (SVC) for temperature management** in patients who have suffered a heart attack. We have considered a simple decision-making model with a short-term horizon combining parameters extracted from the survey carried out within the framework of this study with others taken from the literature. The model is represented in figure 4.2, which has been constructed using the information obtained from the survey completed by 109 hospitals within the Spanish National Health System.

As can be observed in the tree, 38.1% of patients that suffer a cardiac arrest die. These patients are not included within the analysis, therefore we assume that the deaths of these patients are independent of the application or not of temperature control systems (TTM) and the specific TTM procedure used. A small proportion of patients surviving a cardiac arrest (6.1%) are not subjected to any form of TTM procedure, therefore they are also excluded from the analysis.

Therefore, the target population includes **patients surviving a cardiac arrest and who received TTM when admitted to hospital**. In the sample of the study this includes 1,530 patients, a value that is obtained from calculating the average of admissions for cardiac arrest at each hospital that applies TTM, excluding deaths (according to the proportion with a CPC5 state reported by each centre).

Figure 4.2. Decision model for the economic evaluation of servo-control in the temperature management of patients surviving out-of-hospital cardiac arrest



Taking into account **the distribution of survivors according to the CPC neurological state declared by the hospitals on discharge**, and depending on whether they apply a servo-control procedure for controlling temperature or not, they are assigned probabilities associated with each one of said states in the two branches of treatment: "Without servo-control" and "Servo-control". As indicated elsewhere in this report and as can be seen in figure 4.2, the percentage of patients with a good neurological state (CPC1 and CPC2) is significantly higher in the SVC branch and the percentage of patients with a worse state (CPC3 and CPC4) is lower when this type of intervention is applied.

Each one of the final nodes of the decision-making tree is associated with values for costs and effectiveness (outcomes). With regard to costs, these assume the estimates for each CPC presented in the previous sections of this report and which are summarised in table 4.8. With regard to effectiveness, a quality of life has been allocated to the different states (measured in terms of usefulness) based on the literature.

There is a **general consensus regarding the appropriateness of carrying out a CEA** assuming the broadest possible perspective, i.e. that known as social perspective. This implies taking into account all costs associated with the alternatives evaluated, regardless of the situation in which these costs occur. In practice, the social perspective translates into the desirability of computing so-called indirect costs, meaning those arising from productivity losses due to morbidity and mortality associated with each intervention.

Table 4.8. Model inputs. Costs and results in health		
Variable	Value	Reference
Healthcare costs (€/patient)		
No servo-control		
CPC1	27,964	Own estimate (1)
CPC2	30,505	
CPC3	33,581	
CPC4	36,952	
Servo-control		
CPC1	28,634	Own estimate (1)
CPC2	31,175	
CPC3	34,251	
CPC4	37,622	
Indirect costs (€/patient/year)		
CPC1	0	Own estimate (1)
CPC2	22,077	
CPC3	37,259	
CPC4	60,633	
Effectiveness		
Usefulness (quality of life)		
CPC1, CPC2	0.76	Gajarski et al. (2015)[7]
CPC3, CPC4	0.35	
Life expectancy (years)		
CPC1, CPC2	12.5 (2)	Coute et al. (2019)[8]
CPC3, CPC4	8.0 (3)	

(1) Costs per patient estimated from the results of the survey at the 109 hospitals. (2) Patients discharged to the home. (3) Patients discharged to a nursing home ("hospice").

Ideally, a CEA should cover the entire time horizon during which the alternatives covered by the analysis have significant costs and effects, which means calculating the costs and benefits (on health) during the expected survival period of the patients. As can be seen in Table 4.8, estimates of the life expectancy of patients with different neurological states upon discharge after a heart attack have been obtained from the literature.

As previously indicated, the survey designed within the framework of this study has made it possible to obtain information about the consumption of intra-hospital resources, thus allowing the costs per patient to be estimated by referring to secondary sources of information in order to calculate the unit costs for each consumption (market prices, public prices and estimated homogeneous costs in the public health system). The indirect costs have been obtained from the literature, as explained elsewhere in this report. At this time, however, there is no information on the out-of-hospital healthcare costs during the period after discharge, thus making it impossible to perform a complete evaluation under the terms detailed in the previous paragraphs.

The **estimated results for the incremental effectiveness** (health gains) **associated with the use of servo-control procedures** are presented below, as well as necessarily partial results for the incremental costs, as well as some tentative conclusions about the cost-effectiveness of this intervention.

Table 4.9 shows **the expected effectiveness that is obtained using the decision-making model for the comparator (no SVC) and the SVC option**, as well as estimates of incremental effectiveness measured in QALYs. For the calculation within the horizon determined by the life expectancy of the patients (12 and a half years in the case of patients with a good neurological state and eight years in the case of CPC3 and CPC4 patients) a discount rate of 3% has been assumed.

Table 4.9. Incremental effectiveness of the servo-control procedure (QALY per patient)

	No servo-control	Servo-control	Difference (SVC-no SVC)
Short-term	0.607	0.646	0.039
Long-term	2.584	2.924	0.340

In the short term (1 year), the expected values are obtained by applying the probabilities corresponding to each treatment strategy on the decision tree (Figure 4.2) to the usefulness (quality-of-life) on table 4.8. In the long term, these annual expected values are added for the horizon determined by the life expectancy, according to neurological state (Table 4.8), discounting at a rate of 3% from said values.

As can be seen, the use of SVC techniques offers a gain in the short term (one year) of 0.039 QALY, which would ascend to 0.563 QALY (in present value) for a time horizon of 12 and a half years. This means that the use of an SVC procedure gains the equivalent of just under 7 months of life in perfect health (0.563 QALYs × 12 months) for each patient.

Table 4.10 displays the **results referring to the costs that are only shown for the short-term horizon**, due to the previously mentioned limitations. The use of an SVC procedure represents an expected initial additional short-term cost (compared to alternative TTM procedures) of €71 per patient.

Table 4.10. Incremental cost of the servo-control procedure (only short-term healthcare costs in euros per patient)			
	No servo-control	Servo-control	Difference (SVC-no SVC)
Costs	31,215.5	31,285.3	70.8

If we assume this time horizon, the comparison of the incremental cost with the incremental effectiveness gives a cost effectiveness ratio of 2,118 euros per QALY gained (= €70.80/0.563 QALY). In other words, by using the SVC procedure, each year of life in perfect health gained has an additional cost of 2,118 euros. This ICER value would suggest that the SVC techniques are clearly cost-effective, especially as the figure obtained is nearly 10 times lower than the £20,000 established by the British NICE recommendations as the maximum threshold for new technologies to be accepted. It would also be substantially below the most recent estimates carried out in Spain through different methodological approaches[9,10].

However, it must be remembered that the cited value of 2,118 euros/QALY is not a good estimate of the cost effectiveness ratios of the SVC procedure, given that, firstly, it does not consider a complete time horizon and, secondly, it only takes into account healthcare costs (short-term).

If we consider the indirect costs in the amount in which they have been estimated in this study for each neurological state and we assume the survival horizon reported in the literature, in other words, eight years in the case of an unfavourable neurological state (CPC3 and CPC4) and 12 and a half years in patients with a favourable neurological state (CPC1 and CPC2), we obtain the values shown in Table 4.11.

Table 4.11. Indirect cost savings associated with the servo-control procedure in the expected survival horizon of patients according to their condition upon discharge (euros per patient)			
	No servo-control	Servo-control	Difference (SVC-no SVC)
Indirect costs	234,567	202,967	-31,600

The expected values of the costs are obtained by applying the probabilities corresponding to each treatment strategy in the decision tree (Figure 4.2) to the indirect costs according to the CPC in table 4.8, and then adding said expected annual values for the horizon determined by the life expectancy, according to neurological state (Table 4.8), discounting these values at a rate of 3%.

**In spain it's not establish a oficial threshold for the cost by AVAC, that is our comparation of cost-effectiveness from AVAC takes by referring the threshold proposed by NICE, which cause that the study is comparable with other international works, which take as base of comparation the NICE criteria.*

As can be seen, in the **horizon determined by the expected survival of patients with a better neurological state** (12 and a half years), the use of servo-control provides an accumulated saving in indirect costs of 31,600 euros per patient. This is due to the fact that CPC1 patients do not generate indirect costs and it is this group of patients that significantly increases their proportion in the SVC group compared to their representation in the "No servo-control" group.

If we add these medium-term indirect costs to the short-term healthcare costs detailed in Table 4.11, we can conclude that there is a **net saving of 31,671 euros per patient**, which would place this intervention in quadrant II of the cost-effectiveness plane (Figure 4.1), i.e. a procedure that is more effective and less costly than the comparator. These savings would presumably be higher if the expected value of "future" healthcare costs, i.e. after discharge and up to the 12.5 year horizon considered, were taken into account in the calculation of long-term costs. We will briefly explain the reason for this prediction.

The use of SVC techniques is associated with longer survival, as it increases the number of patients with a better neurological state when discharged and decreases the proportion of patients with a worse state, who have a lower life expectancy. In fact, with the probabilities assumed in the tree in Figure 4.2 and assuming that the survival estimates in the literature8, are correct, the average life expectancy without SVC would be 10.8 years and with SVC 11.3, a difference of half a year. This longer survival implies more time receiving medical care and therefore greater healthcare costs in the long term. However, as previously indicated, the increased survival is associated with a better neurological state (a higher proportion of CPC levels 1 and 2), so it is fair to assume that the future healthcare costs would be higher the worse the clinical condition of the patients discharged. For this reason, it can be expected that, if post-discharge healthcare costs were taken into account in the analysis, over the horizon defined by the average life expectancy of the patients, the cost savings would be higher than the 31,671 euros per patient estimated by considering only short-term healthcare costs and indirect costs.

In any event, we do not have the information that allows us to include these costs into the calculation of the incremental cost and the cost-effectiveness ratio, therefore we must emphasise that the analysis presented here is merely approximate.

5. Costes asociados a la parada cardiaca y potenciales ahorros a nivel nacional

In this section we will discuss two aspects of the total number of cardiac arrests today: First of all, we estimate the **annual costs of cardiac arrest** both at national level for Spain and for the Autonomous Communities (AC), which allows us to view the distribution of the economic situation relating to cardiac arrest among the seventeen affected healthcare systems. Secondly, we analyse the **difference in long-term costs** of a cardiac arrest treatment using advanced technology to control temperature.

The estimate of the total annual costs (the year during which the cardiac arrest occurs) for the national total is carried out using the data from the sample returned in the reference survey of this study. Table 5.1 details the estimate of the cardiac arrest costs in Spain and their distribution throughout the autonomous communities. According to this information, the cost of cardiac arrests in Spain was more than 150 million euros. The geographic distribution of this cost depends on the rate of cardiac arrests in each autonomous community, as indicated in the methodology appendix in Annex 4.

Table 5.1. Total annual costs by Autonomous Community in the year in which the cardiac arrest occurs.			
	Estimate Total annual cost	Interval	
National total	€ 154,483,895	€ 141,211,954	€ 167,755,837
Andalusia	€ 20,546,358	€ 18,781,190	€ 22,311,526
Aragon	€ 2,317,258	€ 2,118,179	€ 2,516,338
Asturias	€ 5,870,388	€ 5,366,054	€ 6,374,722
Balearic Islands	€ 5,561,420	€ 5,083,630	€ 6,039,210
Canary Islands	€ 7,106,259	€ 6,495,750	€ 7,716,769
Cantabria	€ 2,780,710	€ 2,541,815	€ 3,019,605
Castile and Leon	€ 12,049,744	€ 11,014,532	€ 13,084,955
Castile La Mancha	€ 6,333,840	€ 5,789,690	€ 6,877,989
Catalonia	€ 27,961,585	€ 25,559,364	€ 30,363,807
Community of Valencia	€ 11,586,292	€ 10,590,897	€ 12,581,688
Extremadura	€ 1,081,387	€ 988,484	€ 1,174,291
Galicia	€ 7,724,195	€ 7,060,598	€ 8,387,792
Community of Madrid	€ 23,790,520	€ 21,746,641	€ 25,834,399
Murcia	€ 5,406,936	€ 4,942,418	€ 5,871,454
Navarre	€ 1,699,323	€ 1,553,331	€ 1,845,314
Basque Country	€ 11,586,292	€ 10,590,897	€ 12,581,688
La Rioja	€ 1,081,387	€ 988,484	€ 1,174,291

The results shown in the previous sections of this study suggest a significant role regarding treatment using advanced technology to manage temperature (SVC versus Other control techniques). **The savings generated by the use of SVC technology**, which we have shown previously, are closely linked to the difference in the distribution of patients on discharge in the different neurological damage states (CPCs) when they are or are not treated with advanced TTM techniques.

We then asked ourselves about the cost differential that would be generated in a simulation framework if the population affected by and surviving cardiac arrest in 2020 had been treated in a scenario involving SVC techniques as opposed to using another technology. Explained in a different manner, we want to know what savings would have been generated for society in the long term if cardiac **arrest survivors in 2020 had been treated using SVC**.

To answer this question we highlight **three chronological milestones relating to the savings accumulated** until the year of discharge, up to seven years after discharge and upon death. Table 5.2 shows this information. It can be seen that in just one year the estimated savings would be €8.7 million, in spite of the fact that approximately 25% of the affected population would have died during that year[11]. The present value of the savings seven years after cardiac arrest is estimated to be around 30 million euros, and reaches approximately 40 million euros when on average the affected population has died. In a scenario in which all structural parameters affecting the management of cardiac arrest, its incidence and evolution, remain constant over successive years, this would imply an updated saving of 40 million for each generation treated for out-of-hospital cardiac arrest in the future.

Table 5.2. Savings and Costs by Generation (cardiac arrests in a given year). SVC vs No SVC scenario (present values)

Milestones	Savings	National Total Costs With SVC treatment	National Total Costs Without SVC treatment
1 year	€ 8,731,970	€ 149,982,977	€ 158,714,947
7 years	€ 29,793,350	€ 142,406,231	€ 172,199,581
Death	€ 39,486,136	€ 188,735,802	€228,221,937

In the preparation of this information we have included several factors and made some assumptions that affect the evolution throughout the expected life of the reference population. These issues are covered in the methodological part of this section.

6. Conclusions

Of all the different recommendations by the ERC for out-of-hospital cardiac arrest, in this study we observed that **only controlling the temperature through the use of servo-control has a positive effect** on the proportion of patients in the different neurological states when discharged.

Turning to the analysis of the costs carried out with the Spanish hospitals that responded to the survey, it is estimated that the **total costs generated in 2020 totalled nearly 84 million euros**. Nearly half of these costs are of a non-healthcare nature. The average and total costs are higher in unfavourable neurological states. In a simulated scenario, compatible with the results of the population analysed, differentiated treatment in temperature control management (TTM) with or without servo-control instruments yields savings of approximately 2.36 million euros (an average saving of 1,452 euros per patient treated in the year of cardiac arrest) and 2.85% savings compared to TTM with alternative techniques. From a cost-effectiveness perspective related to the use of temperature control techniques, **the cost-effectiveness ratio (referring to direct costs) generates a figure 10 times lower than the reference thresholds of the British National Institute for Health and Care Excellence (NICE)** recommendations.

If we increase the estimated costs of the survey for the national total and not only for the sample of the survey of this study, these exceed 150 million euros in the same year that the cardiac arrest occurs. However, if we make a projection of the costs throughout the life of the patient and measure the savings that the use of the servo-control technique would generate compared to other temperature control techniques, we observe that this saving would reach approximately 40 million euros, from the year of the cardiac arrest until the death of the patient. This suggests a very high potential **saving when considering several generations**.

In financial terms, these results indicate that it **is necessary to go into further detail with a study based on a follow-up of the patients**. This would allow the results presented in this report to be corroborated and made more general. Based on the responses provided in the last question of the survey, a good number of hospitals would be prepared to participate in such a study.

References

1. Rosell-Ortiz F, Escalada-Roig X, Fernández Del Valle P, Sánchez-Santos L, Navalpotro-Pascual JM, Echarri-Sucunza A, et al. Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR) Resuscitation. 2017;113:90-95.
2. Ministerio de Sanidad, Consumo y Bienestar Social. Registro OHSCAR. Disponible en: https://www.mscbs.gob.es/biblioPublic/publicaciones/recursos_propios/resp/revista_cdrom/Suplementos/ParadaCardiaca/RegistroOhscar.htm. Acceso: marzo 2021.
3. Ferrer Roca R, Sánchez Salado JC, Chico Fernández M, García Acuña JM, Lesmes Serrano A, López de Sá E, et al. Management of temperature control in post-cardiac arrest care: an expert report. Med Intensiva. 2020 Jul 20:S0210-5691(20)30213-8.
4. Papke LE, Wooldridge JM. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. Journal of Applied Econometrics 1996;11(6):619–32.
5. Matilla-García M, Pérez P, Sanz B. Econometría. McGraw-Hill Interamericana. 2017.
6. Alemi F, Gustafson D. Decision Analysis for Health Managers. Health Administration Press, Chicago. AUPHA Press, Washington, DC. 2006.
7. Gajarski RJ, Smitko K, Despres R, Meden J, Hutton DW. Cost-effectiveness analysis of alternative cooling strategies following cardiac arrest. Springerplus. 2015 Aug 19;4:427.
8. Coute RA, Nathanson BH, Panchal AR, Kurz MC, Haas NL, McNally B, et al. Disability-Adjusted Life Years Following Adult Out-of-Hospital Cardiac Arrest in the United States. Circ Cardiovasc Qual Outcomes. 2019 Mar;12(3):e004677.
9. Vallejo-Torres L, García-Lorenzo B, Serrano-Aguilar P. Estimating a cost-effectiveness threshold for the Spanish NHS. Health Economics 2018;27(4):746-761.
10. Vallejo-Torres L, García-Lorenzo B, Rivero-Arias O, Pinto-Prades JL. The societal monetary value of a QALY associated with EQ-5D-5L health gains. The European Journal of Health Economics 2020;21(3):363-379.
11. Zoch TW, Desbiens NA, DeStefano F, Stueland DT, Layde PM. Short- and long-term survival after cardiopulmonary resuscitation. Arch Intern Med. 2000 Jul 10;160(13):1969-73.

Chapter 4
KEY POINTS

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- Cardiac arrests are a **major public health problem**. There is considerable scope for improving survival, as indicated by the **wide variability of outcomes in the management** of cardiac arrest in both out-of-hospital and in-hospital settings.
- The **successful return of spontaneous circulation** is the first step towards the goal of full recovery from cardiac arrest. In Spain in recent years there has been significant investment in defibrillators and training campaigns for resuscitation procedures. More training in cardiopulmonary resuscitation is needed among the general population, as this specific training in CPR with chest compressions alone could increase bystander CPR.
- Cardiopulmonary resuscitation does not end with the recovery of spontaneous circulation, but with the **return of normal brain function and complete stabilisation of the patient**.
- For those patients with a successful return of spontaneous circulation who arrive at the hospital alive, the **chances of brain damage are very high. Proper post-cardiac arrest hospital management can significantly reduce brain damage in patients**.
- The SEMYCIUC and SEC Societies have carried out a **variability analysis of clinical**, practice, based on the recommendations of the European Resuscitation Council (ERC), in the hospital treatment of patients admitted after suffering a cardiac arrest in Spain, by means of a survey carried out in September 2020 with a total of 115 participants. This analysis shows:
    - That **61.95%** (1,630/2,631) of the patients under study survived, but with different neurological states associated upon discharge: 719 patients (44.11%) left hospital with a very favourable neurological condition (CPC1), 407 (24.97%) with a favourable neurological condition (CPC2), 276 (16.93%) with an unfavourable neurological condition and **228 (13.99%) with a very unfavourable condition**, CPC3 CPC4, respectively.
    - The % survival rates represent a **substantial improvement** compared to those provided by the Ministry of Health taken from the Out-of-Hospital Spanish Cardiac Arrest Registry (OHSCAR project) in which the reported survival rate was only 38,1%(compared to 61.95% reported in this study's survey) and 10.9% survival in the CPC1-2 cerebral neurological scale category (compared to 69.1% reported in this study's survey).
    - There is a **high degree of variability in clinical practice** in the management of post cardiac arrest patients in Spanish hospitals. This variability is common to all sections of clinical management, but is particularly pronounced in the area of temperature control: from the initiation of such control (only 67.8% of participants), through to the place of initiation (70.4% in ICU), the time of initiation (after PCI 50.4%), through to the control

techniques (only half use advanced servo-control devices) and ending with the target temperature (fixed temperature in 54% of participants vs. temperature range 27.3%).

- As part of this project, SEMYCIUC and SEC have commissioned a cost analysis of the variability of post-cardiac arrest hospital management based on the results of the variability analysis. The main conclusions of this economic study are:
  - The cost of post cardiac arrest management in the participating hospitals is **approximately 84 million euros**. Nearly half of these costs are of a non-healthcare nature. The average and total costs are higher in **unfavourable neurological states**.
  - The extrapolation of the cost of post-cardiac arrest management from the survey, for all hospitals in Spain, exceeds **150 million euros the same year**.
  - From the ERC's various recommendations for hospital management after cardiac arrest, and based on the data from this study, it is observed that **only controlling the temperature through the use of servo-control has a significantly positive effect on the proportion of patients with improved neurological states upon discharge**, as per the attached table:

Standardised ratios				
	Low-cost states		High-cost states	
	CPC1	CPC2	CPC3	CPC4
No servo-control	0.379	0.248	0.217	0.156
With servo-control	0.471	0.251	0.143	0.135

  - In a simulated scenario, compatible with the results of the population analysed, differentiated treatment in temperature control management (TTM) with or without servo-control instruments results in a saving over the total sample of approximately **2.36 million euros (an average saving of 1,452 euros per patient treated) and a 2.85% saving over TTM with alternative techniques**. However, if a projection of the costs is made throughout the life of the patient and the savings that the use of the servo-control technique would generate are measured and compared to other temperature control techniques, savings of approximately **40 million euros** are seen, from the year of the cardiac arrest until the death of the patient. From a cost-effectiveness perspective related to the use of temperature control techniques, the cost-effectiveness ratio (referring to direct costs) generates a figure 10 times lower than the reference thresholds of the British National Institute for Health and Care Excellence (NICE) recommendations.

Chapter 5
POSITION

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The **Spanish Society of Intensive and Critical Care Medicine and Coronary Units (SEMYCIUC) and the Spanish Society of Cardiology (SEC)** have launched the CAPAC (Accreditation in Cardiac Arrest Management in Spanish Hospitals) project.

A **comprehensive strategy** for cardiac arrest care must include measures for action in each of the stages:

1. Early recognition of the medical emergency and request for help because a rapid and effective response could prevent a cardiac arrest.
2. Early CPR practised by those witnessing the cardiac arrest because immediate CPR manoeuvres, including chest compression and ventilation (immediate CPR) can double or triple survival in sudden cardiac arrest, gaining time until defibrillation is carried out.
3. Early defibrillation because CPR manoeuvres plus defibrillation in the first 3 to 5 minutes after the cardiac arrest can achieve very high survival rates.
4. Early Advanced Life Support and post-resuscitation care: These measures are essential for recovering a **suitable quality of life**. Appropriate treatment during the post-resuscitation phase affects the outcome of resuscitation.

It must be remembered that, in addition to the preventive measures aimed at reducing the risk factors for suffering a cardiac arrest (both out-of-hospital and in-hospital), other measures are necessary to ensure that the each of the links is strengthened, particularly the **CPR training plans aimed at the general public and healthcare professionals and first responders in particular, which include a minimum of standards defined by expert institutions in this field to guarantee the quality of the teaching**. It should be noted that in-hospital CPR is also considered a life-threatening emergency.

It is also necessary to promote all measures recognised as useful, such as the **general provision of semi-automatic defibrillators, early care equipment, DNR orders, ECPR (extracorporeal cardiopulmonary resuscitation for selected cases and trained teams with promising results), intra-arrest echo-cardioscopy or even generalisation of cardiac compressors or capnography**.

Furthermore, **research and improvement of outcomes** in the treatment of cardiac arrest should encompass all of the links that make up the chain of survival. Without a global approach it is very difficult to achieve improvements in such a demanding process **in all its stages** of care.

In view of all this, it is necessary **to create consistent data recording and communications systems for cardiac arrest and to set up a national institution** which, based on the international recommendations, serves as a reference at a national level for all aspects included in improving cardiac arrest survival rates.

The results of the project have highlighted the **significant variability in the management of cardiac arrest in Spanish hospitals when complying with the recommendations of the European Resuscitation Council (ERC)**. The estimated annual cost of cardiac arrest management in Spain, including such variability, is approximately **150 million euros per year.**

The most significant impact of such variability is the increase in the number of patients leaving hospital with unfavourable neurological states. The project has shown that the **use of servo-control techniques for temperature control is the measure most correlated with improvement in the neurological state of the patients on discharge from hospital**. Only half of the hospitals participating in this project (115 hospitals) use these techniques. The impact of the use of these techniques is shown below in the table of standardised ratios by neurological status (very favourable CPC1, favourable CPC2, unfavourable COC3 and very unfavourable CPC4):

Standardised ratios				
	Low-cost states		High-cost states	
	CPC1	CPC2	CPC3	CPC4
No servo-control	0.379	0.248	0.217	0.156
With servo-control	0.471	0.251	0.143	0.135

The estimated annual savings to the health and social security system from the use of such techniques amount to more than **40 million euros per year**.

On the basis of the results of this project, the Scientific Societies signing this position statement request:

The Ministry of Health

- Launch of a national project for the effective/efficient management of cardiac arrest.

The Autonomous Communities

- The implementation of cardiac arrest units in hospitals with their accreditation based on ERC recommendations.
- The establishment and standardisation of protocols for use in 100% of post cardiac arrest patients.
- The installation of servo-control technology for temperature control in all healthcare centres with accredited cardiac arrest units.

Chapter 6
ANNEXES

Annex 1

Scientific evidence review

Definition of the population of interest. Cardiac arrest

- **Drone-Based Automatic External Defibrillators for Sudden Death? Do We Need More Courage or More Serenity?**
  - *Mark DB, et al. Circulation. 2017 Jun 20;135(25):2466-2469.*

  Out-of-hospital CA (cardiac arrest) is one of the most challenging public health problems in medicine.

- **Cardiac arrest management: any news? When the literature does not meet clinical practice**
  - *Grieco N, Manzoni P. G Ital Cardiol (Rome). 2012 Sep;13(9):583-91.*

  The percentage of patients transported alive to hospital after an out-of-hospital cardiac arrest has risen in recent years thanks to the increase in education of the population. The best possibilities for improving patient outcome are found in the period immediately following the return of spontaneous circulation (ROSC).

- **Devices for rapid induction of hypothermia**
  - *Holzer M. Eur J Anaesthesiol Suppl. 2008;42:31-8.*

  In industrialised countries it is estimated that the incidence of out-of-hospital sudden cardiac arrest is between 36 and 128 per 100,000 inhabitants per year. Almost 80% of patients who initially survive a cardiac arrest are in a coma for more than 1 hour.

- **Out-of-hospital cardiac arrest**
  - *Porzer M, et al.Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2017 Dec;161(4):348-353.*

  Out-of-hospital CA is one of the main causes of death in developed industrialised countries. The average incidence in adults worldwide is 95.9/100,000/year. European incidences vary depending on the source, ranging from 16 to 119/100,000/year.

- **Duration of in-hospital cardiopulmonary resuscitation and its effect on survival**
  - *Cheema MA, et al. Indian Heart J. 2019 Jul - Aug;71(4):314-319.*

  Duration of CPR is inversely associated with rates for establishing ROSC.

- **A strategy for the national health system to address cardiac arrest**
  - *Perales N, et al. 2019.*

  Cardiac arrests (CA) represent a major problem for public health, with it being estimated that in the out-of-hospital setting they cause more than three million deaths worldwide every year.

- **Improving Survival from Out-of-Hospital Cardiac Arrest Acting on the Call**
  - *Global Resuscitation Alliance. 2018.*

  There is a broad margin of action for reducing mortality due to cardiac arrest, as indicated by the high variability in the outcomes of its treatment.

- **Epidemiological characteristics of out-of-hospital cardiorespiratory arrest recorded by the 061 emergencies system (SAMU) in the Balearic Islands (Spain), 2009-2012**
  - *Socias Crespí L, et al. Med Intensiva. 2015 May;39(4):199-206.*

  The variability may be mainly due to epidemiological or socio-demographic factors, the allocation of health resources and/or methodology.

- **Trends in Survival After In-Hospital Cardiac Arrest During Nights and Weekends**
  - *Ofoma UR, et al. J Am Coll Cardiol. 2018:71(4):402-411.*

  The prognosis varies for cardiac arrests that take place in hospitals, not only among the diverse hospitals and nations, but also depending on the time and day on which they take place, with outcomes being worse during the night and at weekends.

- **Regional variation in the incidence, general characteristics, and outcomes of prehospital cardiac arrest in Spain: the Out-of-Hospital Spanish Cardiac Arrest Registry**
    - *Ruiz-Azpiazu JI, et al. Emergencias. 2021 Feb;33(1):15-22.*

  The differences in the incidence of resuscitation attempts, the general characteristics and survival with good neurological status on discharge from hospital are present in the OHCA cases attended by the pre-hospital emergency services of the different Spanish regions.

- **Characteristics Associated With Out-of-Hospital Cardiac Arrests and Resuscitations During the Novel Coronavirus Disease 2019 Pandemic in New York City**
    - *Lai PH, et al. JAMA Cardiol. 2020 Jun 19;5(10):1154–63.*

  A decrease in survival after OHCA has been observed during the Covid-19 pandemic.

- **Economic and social burden of coronary heart disease**
    - *Fernández-de-Bobadilla J, et al. Rev Esp Cardiol Supl. 2013;13(B):42-47.*

  It is essential to point out the need to change some paradigms in order to efficiently address the challenge of cost and the increasing burden of this situation.

- **Long term clinical outcomes in survivors after out-of-hospital cardiac arrest**
    - *Rey JR, et al. Eur J Intern Med. 2020 Apr;74:49-54.*

  Resuscitation should begin as early as possible, since recent studies have shown that approximately 90% of OHCA die before being admitted to hospital, only 10% are admitted to an emergency unit and less than 5% are discharged from hospital.

- **Evolution over time of the prognosis following cardiac arrest based on the updates to the cardiopulmonary resuscitation guidelines**
    - *Marco I, et al. Rev Esp Cardiol. 2020;73(Supl 1):121.*

  Survival without sequelae has increased by 25% between 2006 and 2020.

- **Managing the post-cardiac arrest syndrome. Directing Committee of the National Cardiopulmonary Resuscitation Plan (PNRCP) of the Spanish Society for Intensive Medicine, Critical Care and Coronary Units (SEMICYUC)**
    - *Martín-Hernández H, et al. Med Intensiva. 2010 Mar;34(2):107-26.*

  The high mortality is mainly due to ineffective CPR and, in patients who recover spontaneous circulation and are alive on arrival at hospital, to secondary neurological damage due to hypoxia, which in many cases is extensive and irreversible.

- **Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR)**
    - *Rosell Ortiz F, et al. Resuscitation. 2017;113:90-95.*

  More than half of the cases of sudden cardiac arrest happen in the home and it was found that the population was relatively young. Although recovery was satisfactory in 1 out of 10 patients, the phase prior to the arrival of the emergency team needs to be improved. The coronary intervention procedures had an impact on patient prognosis.

- **Impact of fever on outcome in patients with stroke and neurologic injury: a comprehensive meta-analysis**
    - *Greer DM, et al. Stroke. 2008 Nov;39(11):3029-35.*

  Poor neurological outcomes in patients with cardiac arrest generate significant short and long term costs. Healthcare costs, such as prolongation of the stay in hospital and in intensive care units, and costs unrelated to healthcare, including loss of productivity and those derived from disability allowances.

- **Brain injury and fever: hospital length of stay and cost outcomes**
    - *Reaven NL, et al. J Intensive Care Med. 2009 Mar-Apr;24(2):131-9.*

  Aggressive anti-pyretic treatment can reduce the average hospital stay for these patients at the current levels observed in normothermic patients.

- **Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients**
    - *Diringer MN, et al. Crit Care Med. 2004 Jul;32(7):1489-95.*

  In a large cohort of neurological ICU patients, after controlling the severity of the illness, diagnosis, age and complications, elevated body temperature was independently associated with a longer stay in hospital, a higher mortality rate and a worse outcome.

- **Costs of care after traumatic brain injury**
  - *Ponsford JL, et al. J Neurotrauma. 2013 Sep 1;30(17):1498-505.*

  Demographic factors such as those related to injuries determine the costs following the injury.

- **The long-term health, social, and financial burden of hypoxic-ischaemic encephalopathy**
  - *Euson P. Dev Med Child Neurol. 2015 Apr;57 Suppl 3:48-50.*

  The costs of medical supplies are high, but the indirect costs for the child, their family, as well as social services and the relevant education systems are very often higher. On demonstrating the cost-effectiveness of actions intended to prevent or treat HIE, these additional costs should be taken into account.

- **CPR Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital A Consensus Statement From the American Heart Association**
  - *Meaney PA, et al. Circulation. 2013;128:(4):417-35.*

  Clear definitions of methods for improving the quality of CPR will reduce the gap between the science of resuscitation and the victims, both inside and outside hospital, and will lay the foundations for new improvements in the future.

- **Collaborative Group on Induced Hypothermia for Neuroprotection After Cardiac Arrest. Hypothermia for neuroprotection after cardiac arrest: systematic review and individual patient data meta-analysis**
  - *Holzer M, et al. Crit Care Med. 2005 Feb;33(2):414-8.*

  Mild therapeutic hypothermia improves short term neurological recovery and survival in patients resuscitated after a cardiac arrest presumed to be of cardiac origin. Its long term effectiveness and feasibility at an organisational level require further investigation.

- **Hypothermia for neuroprotection in adults after cardiopulmonary resuscitation**
  - *Arrich J, et al. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD004128.*

  Conventional cooling methods to induce therapeutic hypothermia appear to improve survival and neurological outcome after cardiac arrest. Our review endorses the current improved medical practice according to the International Resuscitation Guidelines.

- **Therapeutic hypothermia initiated in the pre-hospital setting: a meta-analysis**
  - *Cullen D, et al. Adv Emerg Nurs J. 2011 Oct-Dec;33(4):314-21.*

  After resuscitation of the patient with cardiac arrest, cerebral reperfusion activates a chain of events that may cause permanent brain damage. The analysis showed a significant statistical difference with the ability to reduce body temperature when starting pre-hospital cooling immediately, making it possible to initiate therapeutic hypothermia in the pre-hospital setting.

- **Systematic review of randomized controlled trials of therapeutic hypothermia as a neuroprotectant in post cardiac arrest patients**
  - *Cheung KW, et al. CJEM. 2006 Sep;8(5):329-37.*

  Mild therapeutically induced hypothermia reduces hospital mortality and improves neurological outcome in cardiac arrest survivors in a coma.

- **Extracorporeal Cardiopulmonary Resuscitation for Out-of-Hospital Cardiac Arrest in Adult Patients**
  - *Inoue A, et al. J Am Heart Assoc. 2020 Apr 7;9(7):e015291.*

  It has been demonstrated that extracorporeal cardiopulmonary resuscitation (ECPR) followed by targeted temperature management significantly improves the outcomes of out-of-hospital cardiac arrest in adult patients.

AED (automatic external defibrillators)

- **Impact of Automated External Defibrillator as a Recent Innovation for the Resuscitation of Cardiac Arrest Patients in an Urban City of Japan.**
  - *Takeuchi I, et al. J Emerg Trauma Shock. 2018 Jul-Sep;11(3):217-220.*

  Younger patients with out-of-hospital cardiac arrest who were treated with AED (automatic external defibrillators) used by a bystander and achieved out-of-hospital ROSC had more likelihood of reaching a favourable outcome.

- **Changes in automated external defibrillator use and survival after out-of-hospital cardiac arrest in the Nijmegen area.**
  - *Nas J, et al. Neth Heart J. 2018 Dec;26(12):600-605.*

  Survival after discharge has improved considerably by 40-50% after an out-of-hospital cardiac arrest. The use of EAD has doubled.

Healthcare impact of cardiac arrest

- **Cardiac arrest management: any news? When the literature does not meet clinical practice**
  - *Grieco N, Manzoni P. G Ital Cardiol (Rome). 2012 Sep;13(9):583-91.*

  Given the crucial importance of the time that elapses between collapse and CPR in terms of final prognosis, efforts must be made to promote a "culture of cardiopulmonary resuscitation" not only among healthcare professionals, but also among the general population.

Immediate treatment. Optimisation of ventilation and oxygenation

- **Airway and ventilation management during cardiopulmonary resuscitation and after successful resuscitation**
  - *Newell C, et al. Crit Care. 2018 Aug 15;22(1):190.*

  A combination of basic and advanced ventilation and airway techniques should be used during CPR and after return of spontaneous circulation (ROSC).

- **Critical Care of the Post-Cardiac Arrest Patient**
  - *Walker AC, et al. Cardiol Clin. 2018 Aug;36(3):419-428.*

  Early critical attention should be focused on identifying and treating the aetiology of the arrest and minimising additional injuries to the brain and other organs through optimisation of perfusion, oxygenation, ventilation and temperature.

- **Haemodynamic and ventilator management in patients following cardiac arrest**
  - *Topjian AA, et al. Curr Opin Crit Care. 2015 Jun;21(3):195-201.*

  Hyperoxaemia (paO_2> 300 mmHg) and hipoxaemia (paO_2 <60 mmHg) are associated with worse outcomes and hyperventilation can exacerbate the ischaemic cerebral injury through reduction of cerebral oxygenation. Careful attention to normoxaemia and normocapnia can help to avoid secondary injury to organs and potentially improve outcomes.

- **Capnography: A support tool for the detection of return of spontaneous circulation in out-of-hospital cardiac arrest**
  - *Elola A, et al. Resuscitation. 2019 Sep;142:153-161.*

  The current guidelines recommend the use of capnography, but most of the automated methods are based on analysis of the ECG and the thoracic impedance (TI) signals. Adding EtCO2 improves the performance of the automatic pulse detection algorithms based on ECG and TI. These algorithms can be used to identify the on-site pulse and for retrospective identification of cases with ROSC.

Immediate treatment. Haemodynamic parameters

- **Optimal Hemodynamic Parameter to Predict the Neurological Outcome in Out-of-Hospital Cardiac Arrest Survivors Treated with Target Temperature Management**
  - *Yu G, et al. Ther Hypothermia Temp Manag. 2019 Oct 18.*

  The current guidelines suggest maintaining systolic blood pressure at > 90 mmHg and average blood pressure at > 65 mmHg in patients with cardiac arrest. There is still a lack of clarity with respect to the optimal values and the timing of the blood pressure parameters associated with an improvement in the neurological outcome. In comatose survivors with targeted temperature management, the MSI (modified shock index) 6 hours after ROSC had the highest prognostic value for neurological outcome among the blood pressure parameters.

- **Haemodynamic and ventilator management in patients following cardiac arrest**
  - *Topjian AA, et al. Curr Opin Crit Care. 2015 Jun;21(3):195-201.*

  Cardiac arrest is a well-described entity that includes systemic ischaemia-reperfusion response, myocardial dysfunction and neurological dysfunction. Continuous resuscitation in the hours or days after return of spontaneous circulation (ROSC) is important for increasing the likelihood of long term survival and neurological recovery. Post-ROSC hypotension is common and is associated with a worse outcome. Myocardial dysfunction peaks in the first 24 hours after ROSC and is resolved within days in survivors.

- **Post-resuscitation care**
  - *Pothiawala S. Singapore Med J. 2017 Jul;58(7):404-407.*

  The procedures required for post-ROSC care are grouped into a care system: Immediate identification and treatment of the cause of the cardiac arrest; and treatment of electrolyte abnormalities. It is also essential to establish definitive airway management to maintain normocapnic ventilation, prevent hyperoxia and optimise haemodynamic management through appropriate intravenous fluids and vasoactive medications. Targeted temperature management after ROSC gives neuroprotection and leads to improved neurological outcomes. Glycaemic control of glucose levels in blood at 6-10 mmol/L, appropriate handling of convulsions and measures for optimising neurological functions should be included in the care package.

- **Post-ROSC twelve-leads electrocardiogram. Everything in its time**
    - *Savastano S, et al. Resuscitation 130S (2018) e28–e145.*

  The Post-ROSC twelve-leads electrocardiogram is an essential step after a cardiac arrest. However, if acquired too soon it could increase the number of false positives.

- **Crystalloid vs. hypertonic crystalloid-colloid solutions for induction of mild therapeutic hypothermia after experimental cardiac arrest**
    - *Miclescu A, et al. Resuscitation. 2013 Feb;84(2):256-62.*

  No statistical differences were observed between the hypothermic groups in the time taken to achieve mild hypothermia. Although the inclusion of cold hypertonic crystalloid-colloid solutions in early resuscitation after ROSC may be more effective than cold crystalloids in reducing cerebral oedema, this study demonstrates that mild hypothermia induced with small volumes of cold hypertonic crystalloid-colloids is less effective than that induced by crystalloids in the mitigation of brain injury following cardiac arrest.

- **Intra-arterial monitoring during cardiopulmonary resuscitation**
    - *Pierpont GL, et al. Cathet Cardiovasc Diagn. 1985;11(5):513-20.*

  In certain circumstances, emergency intra-arterial monitoring has a potentially important adjuvant role during cardiopulmonary resuscitation.

- **Effects of epinephrine for out-of-hospital cardiac arrest: A systematic review and meta-analysis of randomized controlled trials.**
    - *Huan L, et al. Medicine (Baltimore). 2019 Nov;98(45):e17502.*

  The use of epinephrine led to a significantly higher likelihood of survival after discharge from hospital and ROSC than administration without epinephrine, but there were no significant differences between the groups in the favourable neurological outcome rate.

- **Post-resuscitation care: current therapeutic concepts**
    - *Cokkinos P. Acute Card Care. 2009;11(3):131-7.*

  Patients with return of spontaneous circulation (ROSC) require multidisciplinary implementation of timely reperfusion, appropriate inotropic support and monitoring, glucose control, therapeutic hypothermia and appropriate sedation in the intensive care unit (ICU). Low tidal volume ventilation is preferred (6 ml/kg), and standard vasopressor treatment with dobutamine, dopamine and noradrenaline can be used to improve the patient's haemodynamic profile.

Immediate treatment. Temperature control

- **Cardiac arrest management: any news? When the literature does not meet clinical practice**
    - *Grieco N, Manzoni P. G Ital Cardiol (Rome). 2012 Sep;13(9):583-91. La hipotermia terapéutica debe considerarse como el tratamiento estándar para pacientes comatosos resucitados de un paro cardíaco.*

  Moderate hypothermia is the only treatment for after ROSC, since it is associated with a significant increase in the survival rate.

  It should be started as early as possible, preferably in the pre-hospital setting.

- **Devices for rapid induction of hypothermia**
    - *Holzer M Eur J Anaesthesiol Suppl. 2008;42:31-8.*

  Therapeutic hypothermia provides a highly effective therapy for neuroprotection in patients after a cardíac arrest.

  It is essential for mild hypothermia to be applied very quickly; otherwise, the beneficial effects will be reduced or even cancelled out.

  The optimum time and technique for inducing hypothermia after a cardiac arrest has not yet been defined and is currently an important topic of ongoing research.

  Induction of hypothermia after a cardiac arrest must be an integral component of the initial evaluation and stabilisation of the patient.

- **Improvement of Consciousness before Initiating Targeted Temperature Management**
    - *Su PI, et al. Resuscitation. 2020 Jan 13. pii: S0300-9572(20)30024-1.*

  A significant percentage of patients had spontaneous neurological recovery to GCS M6 within 3 hours after ROSC and had a favourable neurological outcome. Early GCS monitoring should be considered, as well as subsequent initiation of targeted temperature management (TTM) in patients with a substantial probability of neurological recovery.

- **Therapeutic Hypothermia Improves Hind Limb Motor Outcome and Attenuates Oxidative Stress and Neuronal Damage in the Lumbar Spinal Cord Following Cardiac Arrest**
    - *Ahn JH, et al. Antioxidants (Basel). 2020 Jan 1;9(1).*

  Hypothermia improves patient outcomes after resuscitation following a cardiac arrest.

- **Hypothermic to ischemic ratio and mortality in post-cardiac arrest patients**
    - *Skrifvars MB, et al. Acta Anaesthesiol Scand. 2019 Dec 12.*

  We have not found any consistent evidence of a modification of the effect of TTM based on the duration of ischaemia.

- **Temporal trends in the use of targeted temperature management after cardiac arrest and association with outcome: insights from the Paris Sudden Death Expertise Centre**
    - *Lascarrou JB, et al. Crit Care. 2019 Dec 3;23(1):391.*

  We report a progressive reduction in the use of TTM in cardiac arrest patients in recent years.

- **Association of ambient temperature with the outcomes in witnessed out-of-hospital cardiac arrest patients: a population-based observational study**
    - *Ahn C, et al. Sci Rep. 2019 Sep 16;9(1):13417.*

  There is no obvious correlation between the ambient temperature and patient outcomes, such as sustained ROSC or survival after discharge.

- **Mild hypothermia improves neurological outcome in mice after cardiopulmonary resuscitation through Silent Information Regulator 1-actviated autophagy**
    - *Wei H, et al. Cell Death Discov. 2019 Aug 13;5:129.*

  Mild hypothermia treatment improves the neurological function of cardiac arrest patients.

- **The International Liaison Committee on Resuscitation-Review of the last 25 years and vision for the future**
    - *Perkins GD, et al. Resuscitation. 2017 Dec;121:104-116.*

  Care after resuscitation included the concept of TTM (targeted temperature management) with a target temperature of between 32 and 36°C, and the need for delayed multimodal prognosis (more than 24 h after ROSC) in comatose cardiac arrest survivors.

- **Postresuscitation Care after Out-of-hospital Cardiac Arrest: Clinical Update and Focus on Targeted Temperature Management**
    - *Kirkegaard H, et al. Anesthesiology. 2019 Jul;131(1):186-208.*

  Targeted temperature management should be started as quickly as possible and, according to international guidelines, should be maintained between 32° and 36°C for at least 24 hours, while rewarming should not increase by more than 0.5°C per hour. However, uncertainty persists regarding the components of targeted temperature management, warranting further investigation into the optimal cooling rate, target temperature, cooling duration and rewarming rate.

- **Targeted Temperature Management and Postcardiac arrest Care**
    - *Walker AC, et al. Emerg Med Clin North Am. 2019 Aug;37(3):381-393.*

  Targeted temperature management (TTM) has been proven to reduce neurological injury after cardiac arrest and is a cornerstone of post-rest care.

  The optimal dose (defined as the temperature reached multiplied by the duration) of TTM is subject to dispute, but current evidence suggests targeting 32ºC to 36ºC for at least 24 hours There is currently no place for pre-hospital induction of TTM using cold intravenous fluid, and targeted normothermia is the preferred approach in paediatric cardiac arrest.

  Key aspects of post-rest care, in addition to TTM, include ventilator management, haemodynamics, optimisation, identification and treatment of precipitating pathological conditions, and prognosis.

- **Therapeutic Hypothermia in Cardiac Arrest**
    - *Sunde K. Rev Esp Cardiol (Engl Ed). 2013;66(5):346-349.*

  The increased use of TH as part of a standardised, goal-oriented treatment protocol for post-resuscitation care improves survival after out-of-hospital cardiac arrest. Treatment with TH is recommended in the European resuscitation guidelines. Regardless of the cooling method chosen, TH is easy to perform and has no serious side effects or complications associated with mortality. Not only does it have beneficial effects on the brain, but several studies also indicate possible benefits of TH on the heart. Although the benefit provided by TH has only been demonstrated in patients with initial ventricular fibrillation, most centres also use it in comatose patients who have survived other initial heart rhythms if they decide to apply an active treatment. The combination of TH, coronary angiography and PCI is associated with the best clinical outcome. Some controversy remains; the optimal target temperature, the timing of application and the duration of cooling have not yet been defined.

- **Nursing knowledge regarding induced hypothermia after cardiopulmonary arrest: a literature review**
    - *Lázaro Paradinas L. Enferm Intensiva. 2012;23(1):17-31.*

  This work provides evidence of the use of induced TH after CA; and the knowledge and literature necessary for Nursing to play its own part, and implement standardised protocols in our ICUs in this regard.

- **Efficacy of the cooling method for targeted temperature management in post-cardiac arrest patients: A systematic review and meta-analysis**
    - *Kim JG, et al. Resuscitation. 2020 Jan 7;148:14-24.*

  The purpose of this review was to compare the efficacy of endovascular cooling devices (ECD), such as Thermogard®, with surface cooling devices (SCD), such as Arctic Sun, to reduce mortality and improve the neurological status of post-cardiac arrest patients undergoing specific targeted temperature management. The study findings failed to show that ECD or SCD was more effective in terms of survival and improved neurological status for cardiac arrest patients.

- **A comparison between intravascular and traditional cooling for inducing and maintaining temperature control in patients following cardiac arrest**
    - *Rosman J, et al. Anaesth Crit Care Pain Med. 2018 Apr;37(2):129-134.*

  Temperature management with a cooling catheter was associated with faster cooling, better thermal stability in the target range, less over-cooling or overheating, and slower rewarming compared to traditional techniques.

- **Cost-effectiveness analysis of alternative cooling strategies following cardiac arrest**
    - *Gajarski RJ, et al. Springerplus. 2015 Aug 19;4:427.*

  This analysis suggests that blankets are the most cost-effective cooling strategy for post-ROSC therapeutic hypothermia, therefore the cost-effectiveness of alternative cooling modalities designed to improve neurological outcome for this patient population is expanding.

- **Implementation of the guidelines for targeted temperature management after cardiac arrest: a longitudinal qualitative study of barriers and facilitators perceived by hospital resuscitation champions**
    - *Kim YM, et al. BMJ Open. 2016 Jan 5;6(1):e009261.*

  The internal barriers of health professionals for the implementation of TTM can be influenced by new guidelines and can be changed with the accumulation of successful clinical experiences during the initial implementation period. Promoting interprofessional and interdisciplinary collaboration through educational activities and the use of cooling equipment with an automated feedback function can improve adherence to guidelines in hospitals with limited critical care human resources.

- **2-year survival of patients undergoing mild hypothermia treatment after ventricular fibrillation cardiac arrest is significantly improved compared to historical controls**
    - *Storm C, et al. Scand J Trauma Resusc Emerg Med. 2010 Jan 8;18:2.*

  Our study demonstrates that the early survival benefit observed with therapeutic hypothermia persists after two years. This strongly supports compliance with current recommendations regarding post-resuscitation care for all cardiac arrest patients.

- **Body temperature changes are associated with outcomes following in-hospital cardiac arrest and return of spontaneous circulation**
    - *Suffoletto B, et al. Resuscitation. 2009 Dec;80(12):1365-70.*

  Hyperthermia is also associated with fewer patients leaving hospital with favourable neurological outcome.

- **Clinical review: fever in septic ICU patients--friend or foe?**
    - *Launey Y, et al. Crit Care. 2011;15(3):222.*

  Fever is a fundamental diagnostic sign in clinical care, which helps in early and appropriate therapy, and allows doctors to follow the course of the infection.

- **Fever after rewarming: incidence of pyrexia in postcardiac arrest patients who have undergone mild therapeutic hypothermia**
    - *Cocchi MN, et al. J Intensive Care Med. 2014 Nov-Dec;29(6):365-9.*

  Among a cohort of patients who underwent mild TH after OHCA, more than half of these patients developed pyrexia in the first 24 hours after rewarming.

- **Hyperthermia in the neurosurgical intensive care unit**
    - *Kilpatrick MM, et al. Neurosurgery. 2000 Oct;47(4):850-5; discussion 855-6.*

  Fever is common in critically ill neurosurgical patients, especially those with a prolonged duration of ICU stay or cranial disorders. If hyperthermia worsens functional outcome after primary ischaemia or traumatic injury, as several studies of stroke patients have suggested, fever management is a clinical problem that requires better management.

- **Fever and Antipyretic in Critically ill patients Evaluation (FACE) Study Group. Association of body temperature and antipyretic treatments with mortality of critically ill patients with and without sepsis: multi-centered prospective observational study**
    - *Lee BH, et al. Crit Care. 2012 Feb 28;16(1):R33.*

  In non-septic patients, high fever (≥39.5°C) was independently associated with mortality, with no association of NSAID or acetaminophen administration with mortality.

- **Association between hospital post-resuscitative performance and clinical outcomes after out-of-hospital cardiac arrest**
    - *Stub D, et al. Resuscitation. 2015 Jul;92:45-52.*

  Longer survival and a favourable neurological status at discharge were associated with greater adherence to recommended hospital guidelines for post-resuscitation care.

- **Body temperature in acute stroke: relation to stroke severity, infarct size, mortality, and outcome**
    - *Reith J, et al. Lancet. 1996 Feb 17;347(8999):422-5.*

  We have demonstrated that, in acute human stroke, there is an association between body temperature and stroke severity, infarct size, mortality and outcome.

- **Central fever in patients with spontaneous intracerebral hemorrhage: predicting factors and impact on outcome**
    - *Honig A, et al. BMC Neurol. 2015 Feb 4;15:6.*

  Central fever is defined as an elevated temperature without an identifiable cause.

- **Comparison of Two Surface Cooling Devices for Temperature Management in a Neurocritical Care Unit**
    - *Aujla GS, et al. Ther Hypothermia Temp Manag. 2017 Sep;7(3):147-151.*

  The Arctic Sun surface cooling device was more efficient at reaching the target temperature, had a lower incidence of rebound hyperthermia, and was able to maintain normothermia better than the Gaymar cooling wraps.

- **Assessment of risk factors for post-rewarming "rebound hyperthermia" in cardiac arrest patients undergoing therapeutic hypothermia**
    - *Winters SA, et al*

  Although no potential risk factors for rebound hyperthermia were identified, it is a marker of increased mortality and worsening neurological morbidity in cardiac arrest patients who have undergone TH.

- **Therapeutic hypothermia after cardiac arrest: a retrospective comparison of surface and endovascular cooling techniques**
    - *Gillies MA, et al. Resuscitation. 2010 Sep;81(9):1117-22.*

  Therapeutic hypothermia improves both survival and neurological outcome after cardiac arrest.

- **An observational study of surface versus endovascular cooling techniques in cardiac arrest patients: a propensity-matched analysis**
    - *Oh SH, et al. Crit Care. 2015 Mar 16;19(1):85.*

  Various methods and devices for cooling after cardiac arrest have been described, but it remains unclear which is the ideal one.

- **Comparison of external and intravascular cooling to induce hypothermia in patients after CPR**
    - *Flemming K, et al. Ger Med Sci. 2006 Jun 8;4:Doc04.*

  In daily practice, intravascular cooling using a cooling system is better for rapid induction of hypothermia after cardiac arrest.

- **Cooling techniques for targeted temperature management post-cardiac arrest**
    - *Vaity C, et al. Crit Care. 2015 Mar 16;19(1):103.*

  Several cooling methods and techniques are currently available. Available for achieving specific temperature management.

- **Tailored Temperature Management in Neurocritcial Care**
    - *Amey C. European Neurological Review, 2016;11(Suppl. 1):2–4.*

  Currently, optimal temperature thresholds and duration of temperature management must be tailored to the clinical setting and severity of injury, particularly with regard to elevated intracranial pressure.

- **Comparison of cooling methods to induce and maintain normo- and hypothermia in intensive care unit patients: a prospective intervention study**
  - *Hoedemaekers CW, et al. Crit Care. 2007;11(4):R91.*

  Cooling with water circulation blankets, gel pads and intravascular cooling is more efficient compared to conventional cooling blankets.

- **The Implementation of Targeted Temperature Management: An Evidence-Based Guideline from the Neurocritical Care Society**
  - *Madden LK, et al. Neurocrit Care. 2017 Dec;27(3):468-487.*

  Many of the recommendations are conditional and should be put into context in line with the individual needs of the patient and the system.

- **Advanced competencies mapping of critical care nursing: a qualitative research in two Intensive Care Units**
  - *Alfieri E, et al. Acta Biomed. 2017 Jul 18;88(3S):67-74.*

  The role of the nurse has considerable potential and great professionalism with prospects for improvement, if the health system takes them more into account.

Cardiac case diagnosis

Twelve-leads electrocardiogram

- **Post-ROSC twelve-leads electrocardiogram. Everything in its time**
  - *Savastano S, et al. Resuscitation 130S (2018) e28–e145.*

  International guidelines recommend performing a 12-lead electrocardiogram (ECG) after return of spontaneous circulation (ROSC) and emergent coronary angiography at least in patients with ST-segment elevation.

  However, the best time for ECG acquisition after ROSC has never been evaluated.

- **Do combined ultrasound and electrocardiogram-rhythm findings predict survival in emergency department cardiac arrest patients? The Second Sonography in Hypotension and Cardiac Arrest in the Emergency Department (SHoC-ED2) study**
  - *Beckett N, et al. CJEM. 2019 Nov;21(6):739-743.*

  The absence of cardiac activity in POCUS (point-of-care ultrasound), or in ECG and POCUS together, better predicts negative outcomes in cardiac arrest than ECG alone. No test reliably predicted survival.

Coronary angiography

- **Predicting factors for long-term survival in patients with out-of-hospital cardiac arrest - A propensity score-matched analysis**
  - *Lahmann AL, et al. PLoS One. 2020 Jan 15;15(1):e0218634.*

  Immediate coronary angiography is an independent predictive factor of survival in cardiac arrest patients. Improved pre-hospital management can help improve the overall outcome of this critically ill patient population.

- **Outcome predictors of patients with out of hospital cardiac arrest and immediate coronary angiography**
  - *Almalla M, et al. Catheter Cardiovasc Interv. 2019 Nov 12.*

  Advanced age and the inability to achieve ROSC before admission predicted hospital mortality. While coronary angiography with ongoing CPR with the LUCAS device was feasible, mortality in patients without prior ROSC was extremely high, questioning whether this approach is medically useful.

- **Modulating effects of immediate neuroprognosis on early coronary angiography and targeted temperature management following out-of-hospital cardiac arrest: A retrospective cohort study**
  - *Wang CH, et al. Resuscitation. 2019 Oct;143:42-49.*

  Immediate coronary angiography and early TTM should be considered for all out-of-hospital cardiac arrest patients as suggested by guidelines, regardless of the neuroprognosis predicted immediately after ROSC.

- **Coronary Angiography after Cardiac Arrest without ST-Segment Elevation**
  - *Lemkes JS, et al. N Engl J Med. 2019 Apr 11;380(15):1397-1407.*

  Among patients who had been successfully resuscitated after out-of-hospital cardiac arrest and had no signs of STEMI, a strategy of immediate angiography was not found to be better than a strategy of delayed angiography with respect to overall survival at 90 days.

Percutaneous coronary intervention

- **Outcomes of Impella CP insertion during cardiac arrest: A single center experience**
  - *Kamran H, et al. Resuscitation. 2019 Dec 28;147:53-56.*

  The mortality rate for patients undergoing a circulatory assist device during cardiopulmonary resuscitation is 86%.

- **Cardiac arrest management: any news? When the literature does not meet clinical practice**
  - *Grieco N, Manzoni P. G Ital Cardiol (Rome). 2012 Sep;13(9):583-91.*

  It is well known that the majority of patients who experience cardiac arrest without obvious extracardiac causes show significant underlying coronary disease, Hence the importance of the widespread and early use of primary percutaneous coronary intervention.

  Early percutaneous coronary intervention was found to be crucial not only to increase survival, but also to improve neurological outcome after discharge.

- **Cardiac Intensive Care Unit Management of Patients After Cardiac Arrest: Now the Real Work Begins**
  - *Randhawa VK, et al. Can J Cardiol. 2018 Feb;34(2):156-167.*

  There is increasing evidence that an early invasive approach to coronary reperfusion with percutaneous coronary intervention, coupled with active temperature management and optimisation of haemodynamic, ventilator and metabolic parameters, can improve survival and neurological outcomes in cardiac arrest survivors.

Echocardiography

- **Two-dimensional echocardiography after return of spontaneous circulation and its association with in-hospital survival after in-hospital cardiopulmonary resuscitation**
  - *Song IA, et al. Sci Rep. 2020 Jan 8;10(1):11.*

  2D echocardiography can be performed within 24 hours after ROSC to allow for better treatment.

- **Focused cardiac ultrasound after return of spontaneous circulation in cardiac-arrest patients**
  - *Elfwén L, et al. Resuscitation. 2019 Sep;142:16-22.*

  Focused cardiac ultrasound after return of spontaneous circulation in cardiac arrest patients.

STEMI/SCACEST patients

- **Where do I take my patient post ROSC in the absence of ST elevation on the ECG?**
  - *Quinn T. Resuscitation. 2017 Jun;115:A10-A11.*

  Patients with post-ROSC STEMI were thirteen times more likely to be taken directly to the catheter lab than those without. In those without ST elevation who underwent emergency angiography, one third had an acute injury that justified the angioplasty (compared to nearly 80% for those with STEMI).

- **Invasive coronary treatment strategies for out-of-hospital cardiac arrest: a consensus statement from the European association for percutaneous cardiovascular interventions (EAPCI)/stent for life (SFL) groups**
  - *Noc M, et al. EuroIntervention. 2014 May;10(1):31-7.*

  Patients with suspected acute coronary syndrome (ACS) should be treated according to the recommendations for high-risk ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation (NSTE-ACS) without ACS and should undergo immediate (if STEMI) or rapid (less than two hours if NSTE-ACS) invasive coronary strategy. Comatose survivors with ECG criteria for STEMI on post-resuscitation ECG should be admitted directly to the catheterisation laboratory. For patients without STEMI ECG criteria, a brief "emergency department or intensive care unit" stay is recommended to exclude non-coronary causes. In the absence of an obvious non-coronary cause, CAG should be performed as soon as possible (less than two hours), particularly in haemodynamically unstable patients. Immediate PCI should be mainly directed towards the culprit lesion if identified.

- **Clinical characteristics and vital and functional prognosis of out-of-hospital cardiac arrest survivors admitted to five cardiac intensive care units**
  - *Loma-Osorio P, et al. Rev Esp Cardiol (Engl Ed). 2013 Aug;66(8):623-8.*

  The most common cause of out-of-hospital cardiac arrest was some form of ischaemic heart disease (71.1%): dilated ischaemic cardiomyopathy, non-ST segment elevation myocardial infarction, and more predominantly, in 49% of all patients, ST-segment elevation myocardial infarction (STEMI).

Aetiological diagnosis

- **Association Between Multivessel Coronary Artery Disease and Return of Spontaneous Circulation Interval in Acute Coronary Syndrome Patients with Out-of-Hospital Cardiac Arrest**
    - *Tateishi K, et al. Int Heart J. 2019 Sep 27;60(5):1043-1049.*

  Acute coronary syndrome (ACS) is the leading cause of out-of-hospital cardiac arrest.

- **Frailty and associated outcomes and resource utilization following in-hospital cardiac arrest**
    - *Fernando SM, et al. Resuscitation. 2020 Jan 1;146:138-144.*

  Frail people who experience out-of-hospital cardiac arrest are more likely to die in hospital or be discharged from the hospital in the long term, and less likely to achieve ROSC compared to people who are not frail. Hospital costs increase when there is frailty.

- **Neurological outcome and modifiable events after out-of-hospital cardiac arrest in patients managed in a tertiary cardiac centre: A ten years register**
    - *Cassina T, et al.Med Intensiva. 2019 Jul 24.*

  Unconscious patients with documented ventricular tachycardia or fibrillation may benefit from direct admission to a referral heart centre. Initial haemodynamic support, urgent coronary angiography, and targeted management in the cardiac ICU appear to increase the likelihood of good neurological outcomes.

- **Factors associated with the outcome of out-of-hospital cardiopulmonary arrest among people over 80 years old in Japan**
    - *Nagata T, et al. Resuscitation. 2017 Apr;113:63-69.*

  ROSC was the most significant predictor of survival at 1 month among patients with out-of-hospital cardiac and non-cardiac CRA who were ≥80 years old. The absence of ROSC could be an important factor for termination of the resuscitation rule in individuals who are ≥80 years old.

- **Prevalence, therapeutic response, and outcome of ventricular tachycardia in the out-of-hospital setting: a comparison of monomorphic ventricular tachycardia, polymorphic ventricular tachycardia, and torsades de pointes**
    - *Brady WJ, et al. Acad Emerg Med. 1999 Jun;6(6):609-17.*

  Prolonged QTc can be a marker of poor clinical outcome in patients with out-of-hospital cardiac arrest.

Non-cardiac cause diagnosis

- **Early whole-body CT for treatment guidance in patients with return of spontaneous circulation after cardiac arrest**
    - *Viniol S, et al. Emerg Radiol. 2020 Feb;27(1):23-29.*

  An early whole-body CT scan is feasible and provides added diagnostic value for patients with ROSC.

- **Post-resuscitation care**
    - *Pothiawala S. Singapore Med J. 2017 Jul;58(7):404-407.*

  The prevalence of seizures in patients with cardiac arrest is approximately 12% to 20%. They must be treated immediately with benzodiazepines and other anti-seizure medications. The prophylactic administration of anti-seizure medications has no role. EEG should be performed without delay, and readings should be monitored frequently or continuously in comatose patients after ROSC.

- **Survival after Cardiac Arrest Secondary to Massive Pulmonary Embolism**
    - *Laher AE, et al. Case Rep Emerg Med. 2018 Jan 31;2018:8076808.*

  Since outcomes after cardiac arrest after pulmonary embolism (PE) are generally poor, available and potentially vital interventions to restore pulmonary circulation should be implemented quickly when PE is the probable cause of cardiac arrest and this needs to be confirmed by pulmonary angiography.

- **Early in-hospital management of cardiac arrest from neurological cause: Diagnostic pitfalls and treatment issues**
    - *Legriel S, et al. Resuscitation. 2018 Nov;132:147-155.*

  Cardiac arrest due to neurological causes is a rare event that is mainly related to neurovascular causes.

Optimisation of recovery/Prognosis

Management in the ICU

- **Cognitive Impairment among Cardiac Arrest Survivors in the ICU: A Retrospective Study**
  - *Kim SH, et al. Emerg Med Int. 2019 Nov 3;2019:2578258.*

  Cognitive impairment was common immediately after patients regained consciousness, but they made a substantial recovery before discharge from the ICU. Recall and attention/calculation were still affected up to discharge from the ICU, advanced age and increased time to ROSC were associated with this cognitive decline.

- **Cardiac Intensive Care Unit Management of Patients After Cardiac Arrest: Now the Real Work Begins**
  - *Randhawa VK, et al. Can J Cardiol. 2018 Feb;34(2):156-167.*

  The post-cardiac arrest population may differ enough from the general ICU population to warrant a trial in this population. Daily trials of sedation weaning after the initial 72 h of TTM may facilitate early active mobilisation, potentially reducing cognitive dysfunction in the post-arrest patient.

  Delirium is commonplace, manifesting as hypo or hyperactive states. Identifying hypoactive delirium can be difficult, even using well-validated delirium screening tools (for example, the Intensive Care Delirium Screening Checklist and the Confusion Assessment Method in ICU), but it is equally important to treat it, both non-pharmacologically and pharmacologically.

  There is evidence that a vitamin C cocktail reduces the duration of mechanical ventilation and the stay in the ICU, which may be useful for early mobility and for limiting myopathy due to critical illness.

- **Post-resuscitation care**
  - *Pothiawala S. Singapore Med J. 2017 Jul;58(7):404-407.*

  Neuroprognostication in post-cardiac arrest patients is a clinical challenge. Brain injury is the result of an initial ischaemic injury followed by a reperfusion injury that occurs within hours or days after ROSC. Features that indicate brain injury in post-ROSC patients include coma, seizures, myoclonus, and various degrees of neurocognitive dysfunction, ranging from memory deficits to a persistent vegetative state, and eventually brain death.

  The earliest time for prognosis in post-ROSC patients treated with TTM is 72 hours after return to normothermia. In patients who were not treated with TTM, the prognosis should be made 72 hours after cardiac arrest. As such, decisions about a DNR order or withdrawal of care should be avoided for 72 hours after ROSC. However, in cases where patients have an underlying terminal illness, brain herniation, or other non-surviving situations, withdrawal of care before 72 hours may be considered.

- **European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary**
  - *Monsieurs KG, et al. Resuscitation. 2015 Oct;95:1-80.*

  The post-resuscitation care algorithm summarises some of the key interventions required to optimise the outcome for these patients.

  Successful return of spontaneous circulation is the first step toward achieving the goal of complete recovery from cardiac arrest. The complex pathophysiological processes that occur following whole-body ischaemia during cardiac arrest and the subsequent reperfusion response during CPR and after successful resuscitation have been termed post-cardiac arrest syndrome.

  Depending on the cause of the arrest, and the severity of the post-cardiac arrest syndrome, many patients will require multiple organ support and the treatment they receive during this post-resuscitation period significantly influences the overall results and particularly the quality of neurological recovery.

- **An outcome study of adult in-hospital cardiac arrests in non-monitored areas with resuscitation attempted using AED**
  - *Moriwaki K.* Am J Emerg Med. 2019 Dec 14.

  The factors associated with the ROSC rate and those associated with the survival rate after ROSC were different. Although initial shocking rhythms in the AED were not associated with survival rate, dysrhythmia as the aetiology of cardiac arrest and ICU admission were significantly associated with higher survival rates after ROSC.

- **Time to awakening after cardiac arrest and the association with target temperature management**
  - *Lybeck A, et al. Resuscitation. 2018 May;126:166-171.*

  Late awakening is common and often has a good neurological outcome. Time to awakening was longer in TTM33 than in TTM36. This difference could not be attributed to differences in the sedatives administered during the first 48 hours.

- **Protocol-driven neurological prognostication and withdrawal of life-sustaining therapy after cardiac arrest and targeted temperature management**
  - *Dragancea I, et al. Resuscitation. 2017 Aug;117:50-57.*

  Late prognosis was relevant for a minority of patients and was related to later level of care decisions that affected ICU length of stay, survival time and outcome.

- **Performance of a guideline-recommended algorithm for prognostication of poor neurological outcome after cardiac arrest**
    - *Moseby-Knappe M, et al. Intensive Care Med. 2020 Oct;46(10):1852-1862.*

  Evaluating the performance of a four-step algorithm for neurological prognosis after cardiac arrest recommended by the ERC and the ESICM. The ERC/ESICM algorithm and all the multimodal exploratory variations of it investigated in this study predicted poor results without false positive predictions and with sensitivities of 34.6% to 42.5%. Our results need to be validated prospectively, preferably in patients in whom withdrawal from life support therapy is rare in order to exclude any confusion of self-fulfilling prophecies.

- **Influence of the temperature on the moment of awakening in patients treated with therapeutic hypothermia after cardiac arrest**
    - *Ponz I, et al. Resuscitation. 2016 Jun;103:32-36.*

  A high proportion of TTM-induced out-of-hospital cardiac arrest survivors regained consciousness after 5 days, and cooling to a lower target temperature may influence late neurological recovery. Therefore, suspension of life support treatment should be delayed for more than 5 days in patients cooled to 33°C or below. Time until advanced CPR was found to be a predictor of early awakening.

Monitoring and rehabilitation

Procedures and protocol application

- **European Resuscitation Council Guidelines for Resuscitation: 2017 update**
    - *Perkins GD, et al. Resuscitation. 2018 Feb;123:43-50.*

  The mission of the ERC (European Resuscitation Council) is to preserve human life by making high-quality resuscitation available to everyone.

- **Meta-Analysis Comparing Cardiac Arrest Outcomes Before and After Resuscitation Guideline Updates**
    - *Nas J, et al. Am J Cardiol. 2019 Nov 20.*

  The sum of all efforts to improve outcomes, including updated CPR guidelines, contributed to increased survival after cardiac arrest.

- **Implementation of a Team-Focused High-Performance CPR (TF-HP-CPR) Protocol Within a Rural Area EMS System**
    - *McHone AJ, et al. Adv Emerg Nurs J. 2019 Oct/Dec;41(4):348-356.*

  Implementation of a TF-HP-CPR (Team-Focused High-Performance CPR) protocol improved the ROSC rate.

- **One-year experience with fast track algorithm in patients with refractory out-of-hospital cardiac arrest**
    - *Adler C, et al. Resuscitation. 2019 Nov;144:157-165.*

  A fast track algorithm with CPR is feasible, improves neurological outcome and may improve survival in carefully selected patients.

- **An observational study on survival rates of patients with out-of-hospital cardiac arrest in the Netherlands after improving the 'chain of survival'.**
    - *de Visser M, et al. BMJ Open. 2019 Jul 1;9(7):e029254.*

  The optimised 'chain of survival' led to ROSC in 49% of cases and a survival rate after 1 year of 27% in the population studied.

- **Cardiac arrest and cardiopulmonary resuscitation outcome reports**
    - *Perkins GD, et al. Circulation. 2015 Sep 29;132(13):1286-300.*

  It is important to emphasise the need to take into account the factors of the emergency medical services system, the increasing availability of automated external defibrillators, data collection processes, epidemiological trends, the increasing use of assisted cardiopulmonary resuscitation, emerging treatments, post-resuscitation care, prognostic tools and trends in organ recovery.

- **Cardiac Intensive Care Unit Management of Patients After Cardiac Arrest: Now the Real Work Begins**
    - *Randhawa VK, et al. Can J Cardiol. 2018 Feb;34(2):156-167.*

  Survival with a good quality of life after cardiac arrest remains abysmal.

  Subsequent observation and treatment, including neurological injury after cardiac arrest and myocardial dysfunction, the phenomenon of systemic ischaemia-reperfusion with possible consequent multi-organ failure, and the various sequelae of critical illness are significant.

  There is growing evidence that an early invasive approach to coronary reperfusion with percutaneous coronary intervention, coupled with active temperature control and optimisation of haemodynamic parameters, can improve survival and neurological outcomes in cardiac arrest survivors.

- **Mandated 30-minute Scene Time Interval Correlates With Improved Return of Spontaneous Circulation at Emergency Department Arrival: A Before and After Study**
    - *Eastin C, et al. J Emerg Med. 2019 Oct;57(4):527-534.*

  A protocol change requiring a 30 minute scene time interval correlated with an increase in ITS and an increase in ROSC. Although the increase in ROSC may not always be equivalent to a positive neurological result, logistic regression indicated that the protocol change was independently associated with better ROSC upon arrival at the emergency department.

- **Post-resuscitation care for survivors of cardiac arrest**
    - *Mangla A, et al. Indian Heart J. 2014 Jan-Feb;66 Suppl 1:S105-12.*

  Management of these patients is challenging and requires a structured approach that includes stabilisation of cardiopulmonary status, early consideration of neuroprotective strategies, identification and management of the aetiology of arrest, and initiation of treatment to prevent recurrence. This requires a closely coordinated multidisciplinary team effort.

- **Quality indicators and structural requirements for cardiac arrest centres - German Resuscitation Council, (GRC)**
    - *Scholz KH, et al.*

  A working group made up of anaesthesiologists, cardiologists and intensive care physicians, under the umbrella of the German Resuscitation Council has, for the first time, created basic requirements for cardiac arrest centres. These criteria have been agreed by the German Association for Anaesthesiology and Intensive Care, the German Association for Cardiology and Cardiac and Circulatory Research, and the German Association for Intensive Care and Emergency Medicine.

- **Cardiac arrest centres. Improved survival rate after pre-hospital cardiovascular arrest. Qualitätsindikatoren und strukturelle Voraussetzungen für Cardiac-Arrest-Zentren – Deutscher Rat für Wiederbelebung/ German Resuscitation Council (GRC) [Quality indicators and structural requirements for Cardiac Arrest Centres-German Resuscitation Council (GRC)]**
    - *Scholz KH, et al. Anaesthesist. 2017;66(5):360-362.*

  In recent years, enormous efforts have been made in Germany to reduce the ischaemic interval until chest compression in patients with circulatory arrest. The percentage of non-professional resuscitations prior to the arrival of the emergency team should be increased. Furthermore, incorrect transportation to unsuitable hospitals can be avoided.

- **Management of post cardiac arrest syndrome**
    - *Martín-Hernández H, et al. Med Intensiva.2010;34(2):107–126.*

  The International Liaison Committee on Resuscitation (ILCOR) has published a consensus document on "post-cardiac arrest syndrome" and various authors have proposed that post-arrest care be integrated as a fifth link in the chain of survival, after early warning, early bystander CPR, early defibrillation, and early advanced life support.

- **RECALCAR Register. The care of patients with heart disease in the National Health System**
    - *Anguita Sánchez M, et al. Fundación Instituto para le Mejora de la Asistencia Sanitaria (Fundación IMAS). RECALCAR 2018*

  The RECALCAR Report, the seventh edition of which is presented in this monograph, is the result of the efforts of Spanish cardiologists and the Spanish Society of Cardiology (SEC) in the effort to improve the quality of cardiology care in Spain, as well as to increase efficiency in cardiology services and units of the National Health System (SNS).

- **Structural resources of Intensive Medicine Units in Spain**
    - *Martín MC, et al. Med Intensiva. 2013;37(7):443-451.*

  71% of the beds available in critical care units in Spain, which care for seriously ill adult patients, are dependent on the Internal Medicine Services and, for the most part, are multi-purpose.

- **Recommendations for extracorporeal cardiopulmonary resuscitation (eCPR): consensus statement of DGIIN, DGK, DGTHG, DGfK, DGNI, DGAI, DIVI and GRC**
    - *Michels G, et al. Clin Res Cardiol. 2019;108(5):455-464.*

  Extracorporeal cardiopulmonary resuscitation (ECPR) can be considered a rescue attempt for highly selected patients with refractory cardiac arrest and potentially reversible aetiology. Currently, there are no randomised controlled studies on ECPR. Therefore, validated prospective predictors of benefit and outcome are lacking. Currently, the selection criteria and procedural techniques differ between hospitals and standardised algorithms are lacking. Based on expert opinion, this consensus statement provides a first standardised treatment algorithm for ECPR.

- **DETERMINING THE PROFILE FOR NURSING IN CARDIAC INTENSIVE CARE UNITS ACCORDING TO SKILLS**
    - *Roselló Hervás M, et al. Enferm Cardiol. 2012; Año XIX (57):51-58*

  The profile of the CICU nurse, in the absence of a legally recognised speciality, should be: 1. Two years working in general hospitalisation. 2. Training by means of specific courses. 3. Experience for recognising cardiac pathology and rapid action. 4. Attitude of continuous improvement and adaptation to new technologies. Nurses who are new to the CICU should be temporarily supervised by a nurse with sufficient experience. They should also do rounds in other sections of cardiology and ICU to acquire new knowledge and skills. The sum of knowledge, skills and attitudes, plus the length of experience will configure the profile of the appropriate personnel to work in a CICU.

Markers

- **RBM3 and CIRP expressions in targeted temperature management treated cardiac arrest patients-A prospective single center study**
    - *Rosenthal LM, et al. PLoS One. 2019 Dec 10;14(12):e0226005*

  RBM3 (cold-shock proteins RNA-binding motif 3) is a possible candidate for a biomarker to guarantee the efficacy of TTM treatment in patients with cardiac arrest and its pharmacological induction could be a possible future intervention strategy worthy of further investigation.

Scales

- **CaRdiac Arrest Survival Score (CRASS) - A tool to predict good neurological outcome after out-of-hospital cardiac arrest**
    - *Seewald S, et al. Resuscitation. 2020 Jan 1;146:66-73.*

  El CaRdiac Arrest Survival Score (CRASS) represents a tool for calculating the probability of survival with good neurological function for these patients.

- **The cardiac arrest survival score: A predictive algorithm for in-hospital mortality after out-of-hospital cardiac arrest**
    - *Balan P, et al. Resuscitation. 2019 Nov;144:46-53.*

  The cardiac arrest survival score (CASS) accurately predicts mortality. Early risk stratification may allow the identification of more patients in whom prompt and aggressive invasive management can improve outcomes.

- **Physiologic monitoring of CPR quality during adult cardiac arrest: A propensity-matched cohort study**
    - *Sutton RM, et al. Resuscitation. 2016 Sep;106:76-82.*

  The American Heart Association (AHA) recommends monitoring the quality of CPR using end-tidal carbon dioxide (ETCO2) or invasive haemodynamic data.

  The informed use of ETCO2 or DBP by the doctor to control the quality of CPR was associated with improved ROSC. An ETCO2> 10 mmHg during CPR was associated with a higher survival rate compared to events with ETCO2 ≤10 mmHg.

  Survival with a favourable neurological outcome was defined as a cerebral performance category (CPC) score of 1, 2 or no change from the baseline.

- **Team Assessment and Decision Making Is Associated With Outcomes: A Trauma Video Review Analysis**
    - *Dumas RP, et al. J Surg Res. 2020 Feb;246:544-549.*

  Teamwork is a critical element of trauma resuscitation. There are evaluation tools such as T-NOTECHS (Trauma NOn-TECHnical Skills), but correlation with patient outcomes is unclear. The association between the overall T-NOTECHS score and ROSC did not reach statistical significance.

Costs

Economic and social burden of coronary heart disease

- **Economic and Social Burden of Coronary Heart Disease**
    - *Fernández-de-Bobadilla J, et al. Rev Esp Cardiol Supl. 2013;13(B):42-47.*

  To sustain our health system, the clinicians, health economists, health authorities and the biomedical industry would have to try to speak a common language and find a meeting point from the point of view of ischaemic heart disease.

- **Management of post-cardiac arrest syndrome**
    - *Martín-Hernández H, et al. Med Intensiva.2010;34(2):107–126*

  The International Liaison Committee on Resuscitation (ILCOR) has published a consensus document on "post-cardiac arrest syndrome" and various authors have proposed that post-arrest care be integrated as a fifth link in the chain of survival, after early warning, early bystander CPR, early defibrillation, and early advanced life support.

- **Cost analysis of Heart Failure and Ischaemic Heart Disease**
    - *Rodríguez Alonso B, et al. Fundación Gaspar Casal. 2017.*

  The approach to both ischaemic heart disease and heart failure should be carried out by analysing and taking into account economic aspects such as the cost of new treatments, hospitalisations, effects on the productivity of patients, as well as that of their families.

- **Cost-effectiveness of therapeutic hypothermia after cardiac arrest**
    - *Merchant RM, et al. Circ Cardiovasc Qual Outcomes. 2009 Sep;2(5):421-8.*

  In cardiac arrest survivors, therapeutic hypothermia with a cooling blanket improves clinical outcomes with cost-effectiveness that is comparable to many economically acceptable healthcare interventions in the United States.

- **Management of temperature control in post-cardiac arrest care: an expert report**
    - *Ferrer Roca R, et al. Med Intensiva. 2020 Jul 20:S0210-5691(20)30213-8.*

  The focus of this document is also on the practical application of strict temperature control in the recovered cardiac arrest patients in our General or Cardiac Intensive Care Units, mainly on the methods of application, protocols, management of complications and preparation of neurological prognosis.

- **Clinical and economic evidence for intravenous acetaminophen**
    - *Yeh YC, et al. Pharmacotherapy. 2012 Jun;32(6):559-79.*

  Given the currently available clinical and economic evidence, intravenous acetaminophen should not replace oral or rectal use, but its use may be considered in a limited number of patients who cannot receive oral and rectal medications and who cannot tolerate other pain relievers or non-opioid parenteral antipyretics.

- **A randomized study of the efficacy and safety of intravenous acetaminophen compared to oral acetaminophen for the treatment of feve**
    - *Peacock WF, et al. Acad Emerg Med. 2011 Apr;18(4):360-6.*

  A single dose of intravenous acetaminophen is as safe and effective in reducing induced fever as oral acetaminophen. Intravenous acetaminophen may be helpful when patients cannot tolerate the oral route.

- **Effect of paracetamol (acetaminophen) and ibuprofen on body temperature in acute ischemic stroke PISA, a phase II double-blind, randomized, placebo-controlled trial**
    - *Dippel DW, et al. BMC Cardiovasc Disord. 2003 Feb 6;3:2.*

  Treatment with a daily dose of 6000 mg of acetaminophen results in a small but potentially valuable decrease in body temperature after acute ischaemic stroke, even in normothermic and subfebrile patients.

- **Clinical trial of a novel surface cooling system for fever control in neurocritical care patient**
    - *Mayer SA, et al. Crit Care Med. 2004 Dec;32(12):2508-15.*

  The Arctic Sun temperature management system is superior to conventional cooling blanket therapy in controlling fever in critically ill neurological patients.

- **Econometric methods for fractional response variables with an application to 401(k) plan participation rates**
    - *Papke LE, et al. Journal of Applied Econometrics 1996;11(6):619–32.*

  Methods for fractional dependent variables have many applications in economics.

- **Disability-Adjusted Life Years Following Adult Out-of-Hospital Cardiac Arrest in the United States**
    - *Coute RA, et al. Circ Cardiovasc Qual Outcomes. 2019 Mar;12(3):e004677.*

  Non-traumatic cardiac arrest in adults is a leading cause of disability-adjusted annual life years in the US and should be a focus of public health policy and resources.

- **Estimating a cost-effectiveness threshold for the Spanish NH**
    - *Vallejo-Torres L, et al. Health Economics 2018;27(4):746-761.*

  The cost of generating a quality-adjusted life year (QALY) within a health service provides an approximation of the average opportunity cost of financing decisions.

- **The societal monetary value of a QALY associated with EQ-5D-4L health gains**
    - *Vallejo-Torres L, et al. The European Journal of Health Economics 2020;21(3):363-379.*

  There is an extensive body of empirical research that focuses on the social monetary value of a quality-adjusted life year. (MVQALY). Many of these studies have found that the estimates are inversely associated with the size of the health gain, and therefore do not fit the linearity assumption imposed in the QALY model.

- **Short- and long-term survival after cardiopulmonary resuscitation**
    - *Zoch TW, et al. Arch Intern Med. 2000 Jul 10;160(13):1969-73.*

  Survival until discharge from hospital after CPR at our institution over a period of 8 years was higher than previously reported for other institutions.

Clinical guidelines/Scientific societies recommendations

- **Nolan JP, Sandroni C, Böttiger BW, Cariou A, Cronberg T, Friberg H, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2021: Post-resuscitation care. Resuscitation. 2021 Apr;161:220-269.**

- **Nolan JP, Soar J, Cariou A, Cronberg T, Moulaert VR, Deakin CD, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines for Post-resuscitation Care 2015: Section 5 of the European Resuscitation Council Guidelines for Resuscitation 2015. Resuscitation. 2015 Oct;95:202-22.**

- **Nolan JP, Neumar RW, Adrie C, Aibiki M, Berg RA, Böttiger BW, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A Scientific Statement from the International Liaison Committee on Resuscitation; the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; the Council on Stroke. Resuscitation. 2008 Dec;79(3):350-79.**

- **Neumar RW, Nolan JP, Adrie C, Aibiki M, Berg RA, Böttiger BW, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation (American Heart Association, Australian and New Zealand Council on Resuscitation, European Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Asia, and the Resuscitation Council of Southern Africa); the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; and the Stroke Council. Circulation. 2008 Dec 2;118(23):2452-83.**

- **Monsieurs KG, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation. 2015 Oct;95:1-80.**

- **Perkins GD, et al. European Resuscitation Council Guidelines for Resuscitation: 2017 update. Resuscitation. 2018;123:43-50.**

- **Fernández Lozano I, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Key Points. Rev Esp Cardiol (Engl Ed). 2016;69(6):588-594.**

- **American Heart Association. American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015;132(suppl 2):S465–S482.**

- **Soar J, et al. 2019 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2019 Dec;145:95-150.**

- **Panchal AR, Berg KM, Hirsch KG, Kudenchuk PJ, Del Rios M, Cabañas JG, et al. 2019 American Heart Association Focused Update on Advanced Cardiovascular Life Support: Use of Advanced Airways, Vasopressors, and Extracorporeal Cardiopulmonary Resuscitation During Cardiac Arrest: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2019 Dec 10;140(24):e881-e894.**

- Howes D, Gray SH, Brooks SC, Boyd JG, Djogovic D, Golan E, et al. Canadian Guidelines for the use of targeted temperature management (therapeutic hypothermia) after cardiac arrest: A joint statement from The Canadian Critical Care Society (CCCS), Canadian Neurocritical Care Society (CNCCS), and the Canadian Critical Care Trials Group (CCCTG). Resuscitation. 2016 Jan;98:48-63.
- Scaravilli V, Tinchero G, Citerio G; Participants in the International Multi-Disciplinary Consensus Conference on the Critical Care Management of Subarachnoid Hemorrhage. Fever management in SAH. Neurocrit Care. 2011 Sep;15(2):287-94.
- Olasveengen TM, de Caen AR, Mancini ME, Maconochie IK, Aickin R, Atkins DL, et al; ILCOR Collaborators. 2017 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. Circulation. 2017 Dec 5;136(23):e424-e440.
- Perkins GD, Olasveengen TM, Maconochie I, Soar J, Wyllie J, Greif R, et al; European Resuscitation Council. European Resuscitation Council Guidelines for Resuscitation: 2017 update. Resuscitation. 2018 Feb;123:43-50.

Other references of interest

- Sondergaard KB, et al. Out-of-hospital cardiac arrest: 30-day survival and 1-year risk of anoxic brain damage or nursing home admission according to consciousness status at hospital arrival. Resuscitation. 2019 Dec 17.
- Kim SH, et al. Cognitive Impairment among Cardiac Arrest Survivors in the ICU: A Retrospective Study. Emerg Med Int. 2019 Nov 3;2019:2578258.
- Pätz T, et al. Age-associated outcomes after survived out-of-hospital cardiac arrest and subsequent target temperature management. Acta Anaesthesiol Scand. 2019 Sep;63(8):1079-1088.
- Antonaglia V, et al. Impact of Transitory ROSC Events on Neurological Outcome in Patients with Out-of-Hospital Cardiac Arrest. J Clin Med. 2019 Jun 27;8(7).
- Hinson HE, Rowell S, Schreiber M. Clinical evidence of inflammation driving secondary brain injury: a systematic review. J Trauma Acute Care Surg. 2015 Jan;78(1):184-91.
- Brown GC, Neher JJ. Inflammatory neurodegeneration and mechanisms of microglial killing of neurons. Mol Neurobiol. 2010 Jun;41(2-3):242-7.
- Emsley HC, Smith CJ, Tyrrell PJ, Hopkins SJ. Inflammation in acute ischemic stroke and its relevance to stroke critical care. Neurocrit Care. 2008;9(1):125-38.

Annex 2

Questionnaire

GENERAL INFORMATION

Name of the hospital: ____________________

Autonomous Community ________________

City: ____________________

What is your unit? _______________

- Cardiac
- Intensive/multi-purpose

Number of beds in your Unit: ________

Number of admissions of comatose patients for out-of-hospital cardiac arrest per year: _________

CARE OF COMATOSE PATIENTS AFTER OUT-OF-HOSPITAL CARDIAC ARREST (CRA) WITH RETURN OF SPONTANEOUS CIRCULATION (ROSC)

1. **Do you have a post-cardiac arrest protocol?**

   a. Yes

   b. No

2. **Please indicate which protocols you have in place in your Unit: (Multiple answers)**

   a. Referral protocols

   b. Diagnostic approach protocol

   c. Temperature control

   d. Neurological prognosis

   e. Organ donation

   Rank the selected options from most to least important: __________

3. **Which hospital department receives comatose patients recovered from suspected non-cardiac out-of-hospital cardiac arrest (OHCA)?**

   a. Emergency service

   b. Cardiac catheterisation laboratory

   c. ICU/Critical Unit

   d. Otro: _______________

4. **Which hospital service receives comatose patients recovered from suspected cardiac OHCA?**

   a.Emergency service

   b. Cardiac catheterisation laboratory

   c. ICU/Critical Unit

   d. Other: ______________

5. **In which patient populations do you perform coronary angiography and emergent percutaneous coronary intervention (PCI)?**

   a. None

   b. All

   c. Some

Which ones? (Multiple answers)

a. Elevated ST only

b. Any suspicion of acute coronary syndrome

c. Unexplained CRA

d. Refractory cardiac arrest

e. Clinical instability

6. Is there an age limit for not performing coronary angiography and emergent PCI in comatose patients?

a. Yes

b. No

If yes, please indicate what are: __________

7. In ST-elevation acute coronary syndrome (STEACS), do you have a time target for PCI?

a. Yes

b. No

If yes, is it routinely measured?

a. Yes

b. No

If so, what is the time? ____h_____min

8. In actual clinical practice, what is the average time for PCI?

a. 60 minutes

b. 120 minutes

c. 180 minutes

d. 240 minutes

e. 300 minutes

f. 360 minutes

9. Do you carry out regular quality audits?

a. Yes

b. No

10. Do you have a screening protocol for arrhythmogenic diseases?

a. Yes, electrophysiological/pharmacological study

b. Yes, genetic study

c. Both

d. No

STRUCTURE

11. Do you have a PCI service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:_________________

12. Do you have an ultrasound service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:___________________

13. Do you have a CT service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:___________________

14. Do you have an EEG service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:___________________

15. Do you have a neurophysiology service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:___________________

16. Do you have a cardiology service in your centre?

a. Yes, 24 Hours, 7 days a week

b. Yes, but with restricted shift

c. I do not have this service

If you select B, please answer the following question:

Please indicate which:___________________

TEMPERATURE CONTROL MANAGEMENT

17. Do you actively monitor the temperature of comatose patients after out-of-hospital cardiac arrest with ROSC?

a. Yes, for all patients

b. Yes, only in patients with shockable rhythm.

c. No

18. Where does temperature control (TTM) start?

a. Emergency service

b. Cardiac catheterisation laboratory

c. ICU

d. Other: ________________

19. Is TTM initiated before or after PCI?

a. Before PCI

b. During PCI

c. After PCI

20. Do you have a time target for the start of TTM?

a. Yes

b. No

If so, what is the time? ____h_____min

If yes, is it routinely measured?

a. Yes

b. No

21. How do you monitor the temperature? (Multiple answers)

a. It is not generally monitored

b. Antipyretic medication

c. Cold fluids/crystalloids

d. Physical measures: cold compresses, fans/wet towels

e. Non-feedback sheet/water mattress (without servo-control)

f. Hydrogel catheters/patches with advanced servo-control devices

22. Do you perform temperature recovery after TTM?

a. Yes

b. No

If so, what is the time? (Drop-down)

a. <0.1oC/hour

b. 0.1 – 0.25oC/hour

c. 0.26 – 0.5oC/hour

23. Do you have a written TTM protocol?

a. Yes

b. No

24. Does it have a target temperature?

a. Yes

b. No

If yes:

a. It is a fixed temperature: _______

b. It operates in a range: minimum____ maximum____

PROGNOSIS

25. Do you apply prognostic scales in the first 72 hours?

a. Yes

b. No

If yes, please indicate which: __________

26. When is neuroprognosis performed? (Multiple answers)

a. 72 hours after the arrest

b. Immediately after rewarming

c. 72 hours after rewarming

d. I don't have a set time

27. Do you have a protocol to limit therapeutic effort?

a. Yes

b. No

If yes, do you consider donation in end-of-life care?

a. Yes

b. No

28. Indicate which prognostic method you use (Multiple answers)

a. Neurological examination

b. Neuro-specific enolase

c. MRI

d. CT

e. EEG

f. Somatosensory evoked potentials

g. Others: _____________

29. Indicate which assessments are made in the neurological assessment upon discharge (Multiple answers)

a. mRS (Modified Rankin Scale)

b. CPC (cerebral performance category)

c. GOS (Glasgow Outcome Scale)

d. Pupillary reflex

e. Corneal reflex

30. Is there long-term follow-up of patients?

a. Yes

b. No

If yes, where is it done? (Hospital/Health Centre) _______

If yes, how often? (months) _______

31. Do you have a rehabilitation protocol for patients?

a. Yes

b. No

If yes, please indicate which: (Multiple answers)

a. Locomotive rehabilitation

What is the average number of sessions you perform? ______

What is the average duration of rehabilitation? (months)_____

b. Neuro-rehabilitation

What is the average number of sessions you perform?______

What is the average duration of rehabilitation? (months)_____

c. Occupational therapy

What is the average number of sessions you perform?______

What is the average duration of rehabilitation? (months)_____

32. Indicate the percentage of patients per year according to neurological damage on discharge:

a. CPC1 (without sequelae)___________

b. CPC2 (mild disability, is independent, does not require institutionalisation)__________

c. CPC3 (severe disability, not independent, requires institutionalisation) ________

d. CPC4 (persistent vegetative state)___________

e. CPC5 (death)________

33. Indicate, in days, the average length of stay:

a. In the ICU/CU _________

b. In the hospital ________

34. Would you be interested in participating in a prospective register of cardiac arrest management?

a. Yes

b. No

Annex 3

Survey results

Table 1. Results of variability analysis regarding the care of comatose patients after out-of-hospital cardiac arrest (OHCA) and return of spontaneous circulation (ROSC)		
PROTOCOLS	Reply	% (n)
Existence of post cardiac arrest protocol	Yes	75.7 (87)
Protocols in your Unit	Organ donation	91.3 (105)
Major importance protocol	Diagnostic approach protocol Temperature control	39.1 (45) 27.8 (32)
Hospital department receiving comatose patients recovering from out-of-hospital cardiac arrest (OHCA) Presumed non-cardiac Presumed cardiac	ICU/Critical Unit ICU/Critical Unit	67.0 (77) 52.2 (60)
Populations undergoing coronary angiography and emergent percutaneous coronary intervention (PCI)	Some Any suspected of acute coronary syndrome	76.5 (88) 71.6 (63)
Age limit for not performing coronary angiography and emergent PCI in comatose patients	Does not exist	97.4 (112)
Time target for PCI	Yes It is usually measured 61-120 minutes	77.4 (89) 79.7 (71) 67.6 (48)
Average time PCI is performed	120 minutes	45.2 (52)
Conducting of regular audits	No	51.3 (59)
Screening protocol for arrhythmogenic diseases	No	43.5 (50)

Table 2. Results of variability analysis on the structure of healthcare units (staff and tests available in the units).		
ESTRUCTURA UNIDADES	Respuesta	% (n)
PCI service in your centre Shift	Yes, 24 Hours, 7 days a week Morning shifts from Monday to Friday	66.1 (76) 40.0 (4)
Ultrasound service in your centre Shift	Yes, 24 Hours, 7 days a week Morning shifts from Monday to Friday	84.3 (97) 62.5 (10)
CT service in your centre Shift	Yes, 24 Hours, 7 days a week Morning shifts from Monday to Friday	99.1 (114) 100 (1)
EEG service in your centre Shift	Yes, but with restricted shift Morning shifts	70.4 (81) 36.4 (28)
Neurophysiology service in your centre Shift	Yes, but with restricted shift Morning shifts from Monday to Friday	75.7 (87) 29.7 (25)
Cardiology service in your centre Shift	Yes, 24 Hours, 7 days a week Morning shifts	65.2 (75) 39.4 (15)

Table 3. Results of variability analysis on temperature control (temperature control management and protocols)		
TEMPERATURE CONTROL	Reply	% (n)
Active control of the temperature of comatose patients after out-of-hospital cardiac arrest with ROSC	Yes, for all patients	67.8 (78)
Where does temperature control (TTM) start?	ICU	70.4 (81)
Is TTM initiated before or after PCI	After PCI	50.4 (58)
Time target for the start of TTM	No It is usually measured 2h- 12h	65.2 (75) 77.5 (31) 51.2 (20)
Means of temperature control	Hydrogel catheters/patches with advanced servo-control devices Physical measures: cold compresses, fans/wet towels	53.0 (61) 51.3 (59)
Temperature recovery after TTM	Yes 0.1 – 0.25oC/hour	68.7 (79) 52.2 (60)
Written TTM protocol	Yes	58.3 (67)
Target temperature	Yes Fixed temperature Fixed temperature 33ºC Range 34-36ºC	75.7 (87) 54.0 (47) 36.1 (17) 27.5 (11)

Table 4. Results of variability analysis on prognosis (assessment of patients' condition and follow-up)

PROGNOSIS	Reply	% (n)
Application of prognostic scales in the first 72 hours	No	67.8 (78)
Timing of the neuroprognosis	72 hours after the arrest	55.6 (64)
Protocol to limit therapeutic effort	Yes Donation in end-of-life care	80.0 (92) 100 (92)
Method of prognosis	Neurological examination EEG	96.5 (111) 92.2 (106)
Assessments performed in the neurological evaluation upon discharge	GOS (Glasgow Outcome Scale)	61.7 (71)
Long-term follow-up of patients	No Performed at the hospital Every 6 months	71.3 (82) 90.9 (30) 63.6 (21)
Rehabilitation protocol for patients	No Locomotive rehabilitation 6 sessions on average, average duration of sessions 8 months	58.3 (67) 95.4 (42)
Average percentage of patients per year according to neurological damage on discharge	CPC1 (without sequelae) CPC2 (mild disability, is independent, does not require institutionalisation) CPC3 (severe disability, not independent, requires institutionalisation) CPC4 (persistent vegetative state) CPC5 (death)	26% 16% 13% 9% 36%
Average patient length of stay	In the ICU/CU In the hospital	10 days 25 days

Annex 4

Methodological Appendix

Description of the calculation per patient

To calculate the cost per patient of their stay in the ICU we have taken the data of the average stay of patients suffering cardiac arrest in the intensive care units of the 109 hospitals and multiplied this by the average price of each day (average stay) they spend in this unit. We used the same procedure for the hospitalisation cost per patient. To calculate the cost per patient of carrying out a prognosis, we took the average cost of the different methods used in these 109 hospitals to carry out the prognosis of their patients (neurological examination, neurospecific enolase, MRI, CT, EEG, somatosensory evoked potentials). The average cost per patient of the rehabilitation phase shown in Table 4.1 comes from taking the average of the cost of rehabilitation for each one of the neurological states. The cost per session and the number of rehabilitation sessions increases according to the neurological damage suffered by the patient, this being lower in CPC1 and higher in CPC4. Therefore, this data has been obtained by multiplying the price per session by the average number of sessions for each one of the neurological states and then taking the average of these four costs. Lastly, in the healthcare costs block we have the temperature control costs. This cost includes both the cost of inducing hypothermia as well as the warming cost. The cost of the hypothermia phase that we consider here is simply the average cost of this phase. In other words, we are taking into account the average cost of using the different temperature control procedures (servo-control measures, crystalloids, antipyretic medication, etc.). It should be noted that the warming is only carried out on some patients, whereas others are warmed passively which does not incur any costs. Lastly, the average indirect costs per patient are the average of the indirect costs of patients with CPC2, CPC3 and CPC4, which are higher the worse the neurological condition of the patient.

Calculation of the estimation of costs and savings of a generation at national level

The common feature of cardiac arrest data is the low accuracy of the data recording as well as the systematic continuity of data collection. This aspect is widely recognised in the related literature. In particular, the official source explicitly recognises on the website of the Ministry of Health that at this time there is great difficulty in obtaining real data for reliable and up-to-date information regarding the care given to out-of-hospital respiratory cardiac arrest patients in Spain.

The latest official figures published on the incidence of cardiac arrest in Spain and its geographical distribution refer to a period of thirteen months in the years 2013 and 20141. There have been very interesting initiatives with remarkable results for understanding the incidence and major factors affecting the process of cardiac arrest management derived from the OHSCAR registry. However, this registry was discontinued and was incomplete.

The study into national costs is based on up-to-date data from 2020 using the survey carried out in this study. An estimate will be made of the national total cases that reach hospital with a pulse, as well as the national total of survivors upon discharge. With regard to the distribution of the incidents per Autonomous Community, these figures will be calculated using the Tables published in Rosell-Ortiz, F. et al. (2017) and Ruiz-Azpiazu et al. (2021)[1,2].

Table A.1: Distribution of cardiac arrests by Autonomous Community	
	% cases included (incidents)
National total	100,00
Andalucía	13,30
Aragón	1,50
Asturias, Principado de	3,80
Balears, Illes	3,60
Canarias	4,60
Cantabria	1,80
Castilla y león	7,80
Castilla - La Mancha	4,10
Cataluña	18,10
Comunitat Valenciana	7,50
Extremadura	0,70
Galicia	5,00
Madrid, Comunidad de	15,40
Murcia, Región de	3,50
Navarra, Comunidad foral de	1,10
País Vasco	7,50
Rioja, La	0,70

It is estimated from the sample collected in this study that the number of cases that arrived with a pulse at the hospital after cardiac arrest in 2020 was 4,012 cases, of which 2,467 survived to discharge. These figures make it possible to induce an incidence of 28% per 100,000 in this reference year. This level of incidence is above 23.3%, which was the last data officially available by the Ministry of Health and referring to 2017-2018.

The estimated long-term saving in the use of servo control versus no servo control that has been presented in this report has taken various aspects into consideration, among which we highlight the following:

- The long-term outcomes in the population that has survived a cardiac arrest. These compared outcomes have been taken into consideration in the preparation of the survival rates of the affected population. In particular, we have used the results presented by Zoch et al. (2000)3.

- The time references presented in Table 5.2 correspond to survival time markers analysed in Zoch et al. (2000)3.
- The average age considered for the population that suffered a cardiac arrest was 64.2 years. This datum was obtained from the publications of the Statistical Information Portal of the Ministry of Health, referring to 2019. The life expectancy used was that reported in the Mortality Tables of the National Institute of Statistics (INE)[4].

Individuals and institutions, whether health or non-health, are not indifferent to the point in time at which the costs of a programme occur. The time preference has to be incorporated into the financial evaluation by introducing adjustments to the future magnitudes that make it possible to express them at their current value, i.e. their present equivalent value. This adjustment operation is known as discounting, and it consists of multiplying the future quantities by a discount factor, which depends on the time preference rate and how far away in time the moment when the cost was incurred or the benefit was enjoyed is.

The application of the discount procedure to each of the components of a cost flow associated with a programme makes it possible to determine the current value of the costs, in the following way:

$$VA(C_i) = \sum_{t=0}^{n} \frac{C_i(t)}{(1+r)^t}$$

Where:

i indicates whether it is SV or noSV
VA(Ci) is the current value of the costs associated with i
Ci(t) are the costs of the programme i in the period t
r = discount rate
n = duration of the project

Individually considered, the relevant discount rate is the market interest rate since this represents the cost of opportunity of the private investments. However, in the evaluation of public projects in general or of healthcare programmes in particular, the point of view of society is assumed and, therefore, we would think about a social discount rate.

In this study we used a pragmatic approach and opted for the use of a discount rate that was consistent with the literature, i.e. with the studies conducted to date, as well as trying to use discount rates that allow a comparison with the studies conducted in other geographical areas. In this spirit of pragmatism, a discount rate of 5% meets these requirements as it is the one suggested by the assessment guidelines from other countries, such as Canada and the British National Institute for Clinical Excellence (NICE).

From a theoretical point of view, it should be mentioned that there are two main options for setting the discount rate in the economic assessment: a) The social opportunity cost approach, which advocates the use of the real rate of return on private sector investment, a magnitude that is difficult to estimate empirically. b) The social rate of time preference approach, which proposes the use of the interest rate on risk-free investments, which in practice means identifying the social discount rate with the real interest rate, i.e. after inflation, on long-term debt.

References

1. Rosell-Ortiz F, Escalada-Roig X, Fernández Del Valle P, Sánchez-Santos L, Navalpotro-Pascual JM, Echarri-Sucunza A, et al. Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR) Resuscitation. 2017;113:90-95.
2. Ruiz-Azpiazu JI, Daponte-Codina A, Fernández Del Valle P, López-Cabeza N, Jiménez-Fàbrega FX, Iglesias-Vázquez JA, et al. Regional variation in the incidence, general characteristics, and outcomes of prehospital cardiac arrest in Spain: the Out-of-Hospital Spanish Cardiac Arrest Registry. Emergencias. 2021 Feb;33(1):15-22.
3. Zoch TW, Desbiens NA, DeStefano F, Stueland DT, Layde PM. Short- and long-term survival after cardiopulmonary resuscitation. Arch Intern Med. 2000 Jul 10;160(13):1969-73.
4. Instituto Nacional de Estadística, Índice de precios al consumo. Disponible en: https://www.ine.es/calcula/. Acceso: marzo 2021.

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