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European Resuscitation Council Guidelines 2021: Executive summary

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Abstract

Informed by a series of systematic reviews, scoping reviews and evidence updates from the International Liaison Committee on Resuscitation, the 2021 European Resuscitation Council Guidelines present the most up to date evidence-based guidelines for the practice of resuscitation across Europe. The guidelines cover the epidemiology of cardiac arrest; the role that systems play in saving lives, adult basic life support, adult advanced life support, resuscitation in special circumstances, post resuscitation care, first aid, neonatal life support, paediatric life support, ethics and education.

Introduction

The European Resuscitation Council (ERC) objective is to preserve human life by making high quality resuscitation available to all.[1] This includes producing up-to-date evidence-based European guidelines for the prevention and treatment of cardiac arrest and life threatening emergencies.

The first ERC guidelines were presented in Brighton in 1992 and covered basic[2] and advanced life support.[3] In 1994, Guidelines for

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[1] See Appendix A.

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Paediatric Life Support (PLS)[4] and Guidelines for the Management of Peri-arrest Arrhythmias[5] followed at the second Congress in Mainz, with Guidelines for the Basic and Advanced Management of the Airway and Ventilation during Resuscitation at the third Congress in Seville in 1996,[6] and updated Guidelines at the 4th Scientific Congress of the ERC in Copenhagen in 1998.[7,8] In 2000, international guidelines were produced in collaboration with the International Liaison Committee on Resuscitation (ILCOR)[9] which the ERC went on to summarise in 2001.[10] After this, ERC guidelines were produced every 5 years: 2005,[11] 2010[12] and 2015.[13] From 2017 the ERC has published annual updates[14,15] linked to the publications of ILCOR Consensus on Science and Treatment Recommendation (CoSTR) publications.[16,17] In 2020, guidelines were published covering resuscitation in the context of coronavirus disease 2019 (COVID-19).[18] These 2021 ERC Guidelines present a major update on resuscitation science and provide the most up to date evidence-based guidelines for by laypersons, healthcare providers and those responsible for health policy across Europe.

International Liaison Committee on Resuscitation

ILCOR exists to save more lives globally through resuscitation.[19,20] This vision is pursued through promoting, disseminating and advocating for international implementation of evidence-informed resuscitation and first aid, using transparent evaluation and consensus summary of scientific data. The ERC as one of the founding members of ILCOR and continues to work closely with ILCOR in pursuit of those goals.

A key activity of ILCOR is the systematic assessment of evidence to produce international consensus on science with treatment recommendations. Produced initially every 5 years, ILCOR transitioned to a continuous evidence evaluation in 2017. The 2020 CoSTR was published in October 2020 and comprises 184 structured reviews of resuscitation science[21–29] which inform the ERC Guidelines presented here.

Guideline development process

Healthcare systems rely increasingly on high-quality, evidence-informed clinical practice guidelines. As the influence of such guidelines has grown and the rigour of the evidence evaluation process informing the content of guidelines has increased, attention has turned to raising the standards and transparency for the guideline development process.[30]

The Institute of Medicine established quality standards for clinical practice guidelines in 2011,[31] shortly followed by the Guidelines International Network.[32] The ERC Guidelines followed the principles for guideline development developed by the Guidelines International Network.[32] This includes guidance on panel composition, decision-making process, conflicts of interest, guideline objective, development methods, evidence review, basis of recommendations, ratings of evidence and recommendations, guideline review, updating processes, and funding. A written protocol describing the guideline development process was developed and approved by the ERC Board before the start of the guideline development process.

Composition of Guideline Development Group

The ERC Articles of Incorporation and Bylaws (https://erc.edu/about) set out the formal process by which the ERC appoints its Guideline Development Committees. The Director of Guidelines and ILCOR is elected by the General Assembly of the ERC and mandated to co-ordinate the guideline process. They were supported by a Guideline Development Committee comprising: Director Guidelines and ILCOR (Chair), Co-chair Science for the four standing committees (BLS/AED; ALS; PLS; NLS), Other members (Director of Training, Director of Science, ERC Vice Chair, ERC Chair, Editor-in-Chief Resuscitation, Writing group chairs) and ERC staff.

The ERC Board identified the topics included in the ERC Guidelines and appointed the writing group chairs and members. Following a review of conflicts of interest (as described below) writing group chairs and members were appointed by the Board. Members were appointed based on their credibility as leading (or emerging) resuscitation scientists/clinicians/methodologists and to ensure a balance of professions (medicine, nursing, paramedicine), early career members, gender and ethnicity, geographical balance across Europe and representatives of key stakeholder organisations. The appointed writing groups ranged in size from 12–15 members. Most writing group members were physicians (88%), who worked alongside clinicians from a nursing, physiotherapy and occupational therapy backgrounds as well as research scientists. A quarter of the writing group members were female, and 15% were early in their careers. The writing groups came from 25 countries including Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, France, Germany, Greece, Holland, Iceland, Ireland, Italy, Netherlands, Norway, Poland, Romania, Russia, Serbia, Spain, Sudan, Sweden, Switzerland, United States of America and United Kingdom.

The role description for writing group members comprised:

- Provide clinical and scientific expertise to the guideline writing group.
- Actively participate in the majority of guideline writing group conference calls.
- Systematically review the published literature on specific topics at the request of the guideline writing group.
- Present review findings and lead discussions within the group on specific topics.
- Develop and refine clinical practice algorithms and guidelines.
- Fulfil the International Committee of Medical Journal Editors (ICMJE) requirements for authorship.
- Be prepared to be publicly accountable for the contents of the guidelines and promote their adoption.
- Comply with the ERC conflict of interest policy.

Decision making processes

The ERC guidelines are based on the ILCOR CoSTRs.[21–29] Where treatment recommendations are provided by ILCOR, these have been adopted by the ERC. In areas where no relevant treatment recommendation existed the method used to arrive at recommendations was based on review and discussion of the evidence by the working group until consensus was achieved. The writing group chairs ensured that each individual on the working group had the opportunity to present and debate their views and ensured that discussions were open and constructive. All members of the group needed to agree to endorse any recommendations. Any failure to reach consensus is made clear in the final wording of the recommendation. The quorum for conducting writing group business and reaching consensus will be at least 75% of the writing group.

The guideline scope and final guidelines were presented to and approved by the ERC General Assembly.

Conflict of interest

Conflict of interest (COI) was managed according to the ERC policy for COI (see supplemental material). Writing group members completed an annual COI declaration. The COI declaration was reviewed by the Governance Committee and a report prepared for the ERC Board. Writing group member conflicts were posted on the ERC website through the guideline development process.[33]

The writing group chair and at least 50% of the writing group were required to be free of commercial conflicts of interest. At the chair's discretion, writing group members with a COI were still able to participate in discussions that relate to this topic, but were not involved in drafting or approving recommendation.

The ERC has financial relationships with business partners who support the overall work of the ERC.[34] The development of the ERC guidelines occur entirely independently from the influence of business partners.

Scope of guidelines

The ERC guidelines provide guidance through its network of 33 national resuscitation councils. The intended audience are lay-persons, first aiders, first responders, community healthcare staff, ambulance staff, hospital staff, trainers and instructors, and those responsible for healthcare policy and practice. The guidelines are relevant for use in both the community (out-of-hospital) and hospital (in-hospital) settings. The scope of individual guideline sections was developed by the writing groups at the start of 2019. The guideline scopes were posted for public consultation for 2 weeks in May 2019 prior to being finalised and approved by the ERC General Assembly in June 2019.

The Guidelines cover the following topics

- Epidemiology[35]
- Systems saving lives[36]
- Adult basic life support[37]
- Adult advanced life support[38]
- Special circumstances[39]
- Post resuscitation care (in collaboration with the European Society of Intensive Care Medicine)[40]
- First Aid[41]
- Neonatal life support[42]
- Paediatric life support[43]
- Ethics[44]
- Education[45]

Methods

The step-by-step process for guideline development is summarised in Fig. 1. In brief the ERC Board defined the topic areas that would be covered in the guidelines and appointed the writing groups. The writing groups developed the scope using a standardised template. The scope contained the overall objective, intended audience, setting for their use and the key topics that would be covered. The guideline scopes were presented for public comment, revised, and then approved as described in the previous section. Writing groups then proceeded to identify and synthesise the relevant evidence which were then summarised and presented as the guideline recommendations. The draft guidelines underwent a further period of public consultation before peer review and approval by the General Assembly.

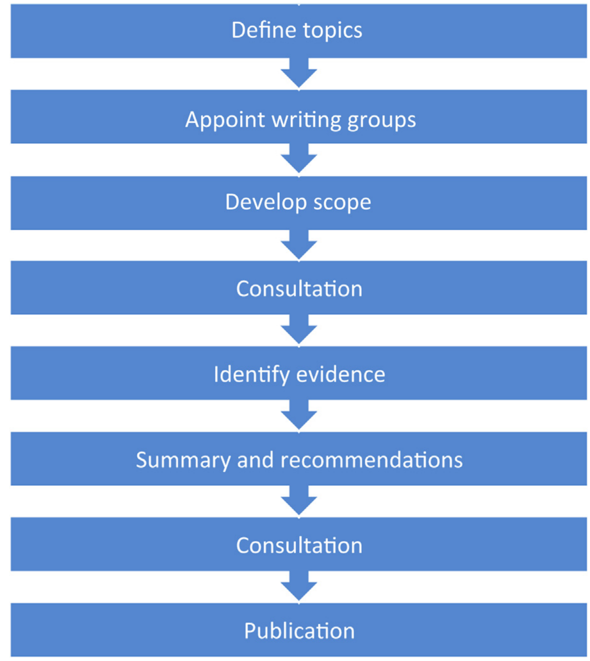

Fig. 1 – Step-wise process for development of the ERC guidelines.

Evidence reviews

The ERC Guidelines are informed by the ILCOR Evidence Evaluation process which is described in detail elsewhere.[23] In summary, ILCOR has undertaken three styles of evidence evaluation since 2015 comprising systematic reviews, scoping reviews and evidence updates.

The ILCOR systematic reviews follow the methodological principles described by the Institute of Medicine, Cochrane Collaboration, and Grading of Recommendations Assessment, Development, and Evaluation (GRADE).[46] The reviews are presented according to the Preferred Reporting Items for a Systematic Review and Meta-Analysis (PRISMA) (Table 1).[47]

ILCOR systematic reviews were supplemented by scoping reviews, undertaken either directly by ILCOR or by members of the ERC writing groups. Unlike systematic reviews (which tend to have a focused/narrow question), scoping reviews take a broader approach to a topic and seek to examine and map the extent, range and nature of research activity.[23] This enabled the guideline group to produce narrative summaries across a broader range of subjects than would be possible through solely conducting systematic reviews. Scoping reviews followed the framework outlined by ILCOR and were reported in accordance with the PRISMA extension for scoping reviews.[48] Unlike systematic reviews, neither the ILCOR nor the ERC scoping reviews could lead to a formal CoSTR.

The final method of evidence evaluation used by ILCOR were evidence updates.[23] These were designed to address topics that had not been formally reviewed for several years, in order to identify if any new evidence had emerged to that should prompt a formal review. Evidence updates either provided assurance that previous treatment recommendations remained valid or highlighted the need to update a previous systematic review. In themselves, evidence updates did not lead to any changes to CoSTR.

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Table 1 – Summary outline of the process steps for the 2020 CoSTR SysRevs (reproduced from[23]).

Task forces select, prioritise, and refine questions (using PICOST format)
Task forces allocate level of importance to individual outcomes
Task forces allocate PICOST question to SysRev team*
SysRev registered with PROSPERO
SysRev team works with information specialists to develop and fine-tune database-specific search strategies
Revised search strategies used to search databases
Articles identified by the search are screened by allocated members of the SysRev team using inclusion and exclusion criteria
SysRev team agrees on final list of studies to include
SysRev team agrees on assessment of bias for individual studies
GRADE Evidence Profile table created
Draft CoSTRs created by SysRev team
Evidence-to-decision framework completed by task force
Public invited to comment on draft CoSTRs
Detailed iterative review of CoSTRs to create final version
Peer review of final CoSTR document

Footnote: CoSTR indicates Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; PICOST, population, intervention, comparison, outcome, study design, time frame; PROSPERO, International Prospective Register of Systematic Reviews; and SysRev, systematic review. *Systematic review team could be knowledge synthesis unit, expert systematic reviewer, or task-force-led team involving content experts from the ILCOR task force(s), and delegated member of the Continuous Evidence Evaluation Working Group and Scientific Advisory Committee.

Systematic reviews from other organisations were eligible for inclusion if they were conducted and reported according to AMSTAR (Assessing the methodological quality of systematic reviews)[49] and PRISMA[47] recommendations, are in the public domain and have been peer reviewed.

Where topics of interest fell outside the remit of evidence reviewed by ILCOR, ERC writing groups undertook scoping reviews to map the available evidence and synthesis key information and themes, using the same approach undertaken by ILCOR.

Guideline recommendations

Concise guidelines for clinical practice

Most ERC guidelines will be used in emergencies where efficient, timely action is critical. The concise guidelines for clinical practice sections are intended to provide clear, succinct recommendations with easily understood algorithms to provide the reader with unambiguous, step by step instructions. As such, these components of the guidelines do not include information about the level of evidence or strength of recommendations. Instead, this information is presented in the evidence informing the guidelines sections.

Evidence informing the guidelines

Formal ERC treatment recommendations are limited to those informed by ILCOR CoSTR. The ILCOR CoSTRs are constructed following a rigorous evidence evaluation informed by GRADE. The detailed steps are described in the ILCOR Evidence Evaluation Process Summary. In brief these treatment recommendations provide a summary of the certainty of evidence and a strength of recommendation. The certainty (quality) of evidence ranges from very low to high (see Table 2).

Table 2 – Certainty (quality) of evidence for a specific outcome (or across outcomes).

GRADE certainty level	Description
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

The strength of recommendations from ILCOR reflect the extent to which the task force was confident that the desirable effects of an action or intervention outweighed the undesirable effects. Such deliberations were informed by the Evidence to Decision Framework developed by GRADE which enables consideration of the desirable effects, undesirable effects, certainty of evidence, values, balance of effects, resources required, certainty of evidence of required resources, cost effectiveness, equity, acceptability and feasibility. There were two main strengths of recommendation – a strong recommendation indicates that the task force was confident that desirable effects outweigh the undesirable effects. Strong recommendations typically use terms such as 'we recommend'. Weak recommendations (where the task force was not confident that the desirable effects outweigh the undesirable effects) typically use the term 'we suggest'.

There are many areas of resuscitation science where there is either no evidence or insufficient evidence to inform an evidence-based treatment recommendation. When this occurs the expert opinion of the writing group is presented. The guidelines clearly document which aspects of the guideline are evidence informed versus expert consensus.

Stakeholder consultation and peer review

Drafts of the ERC Guidelines were posted on the ERC website for public comment between 21st October 2020 and 5th November 2020. The opportunity to comment on the guidelines was advertised through social media (Facebook, Twitter) and the ERC network of 33 national resuscitation councils. The guideline content for each section was also presented via a short (15 min) video presentation as part of the ERC 2020 Virtual Conference followed by open questions and a panel discussion. Those providing feedback had to identify themselves and highlight any relevant conflict of interest.

164 written responses were received. Those responding comprised physicians (45%), nurses (8%), ambulance staff (28%), other (11%), education (5%), lay persons (3%). 15% declared a conflict of interest of which two thirds were commercial conflicts and one third academic. Feedback comments were distributed to the chairs of the relevant section and considered in full by the writing group. Where relevant changes were made to the respective sections.

A final draft of the guidelines was submitted to members of the ERC General Assembly for peer review in December 2020. Writing group chairs (or their deputies) responded to queries and the final set of guidelines was approved and submitted for publication at the end of December 2020.

Guidance updates

ILCOR entered a continuous evidence evaluation process in 2016. CoSTRs are published on the ILCOR website as they are completed. This is supplemented by an annual summary published in Circulation and Resuscitation.

The ERC welcomes the new, more responsive approach to evidence synthesis developed by ILCOR. In embracing this approach, the ERC has considered how best to integrate any changes prompted by ILCOR into our guidelines.

The ERC recognises the substantial time, effort and resources required to implement changes to resuscitation guidelines. The ERC is also cognisant of the confusion that could be caused by frequent changes to guidelines, which could impair technical and non-technical skill performance and adversely impact patient outcomes. Nevertheless, if new science emerges which presents compelling evidence of benefits or harms, prompt action must be taken to translate it immediately into clinical practice.

To balance these conflicting priorities, the ERC has decided to maintain a 5-yearly cycle for routine updates to its guidelines and course materials. Each new CoSTR published by ILCOR will be reviewed by the ERC Guidelines Development Committees who will assess the likely impact of the new CoSTR on our guidelines and education programmes. These committees will consider the potential impact of implementing any new CoSTR (lives saved, improved neurological outcome, reduced costs) against the challenges (cost, logistical consequences, dis-semination and communication) of change. CoSTRs which present compelling new data which challenge the ERC's current guidelines or educational strategy will be identified for high priority implementation; guidelines and course materials will then be updated outside the 5-year review period. By contrast, new information which will lead to less critical, incremental changes to our guidelines will be identified for lower priority implementation. Such changes will be introduced during the routine, 5-yearly update of guidelines.

Availability

All ERC guidelines and updates will be freely available to access through the ERC website and as a publication in the ERC official journal, *Resuscitation*.

National Resuscitation Councils can translate ERC guidelines for use locally.

Financial support and sponsoring organisation

The Guidelines are supported by the European Resuscitation Council (ERC). The ERC is a non-profit organisation in accordance with the Belgian Law of 27 June 1921. The articles for incorporation and internal rules governing the ERC are available at: https://erc.edu/about. A budget is set annually by the ERC Board to support the Guideline Development Process.

The official journal of the ERC is *Resuscitation*, an international peer reviewed journal hosted by Elsevier. The Editor in Chief maintains the editorial independence of the journal and sits on the ERC Board. Guidelines are usually published in *Resuscitation.*

COVID-19 guidelines

The ERC published guidelines to support lay persons and healthcare professionals to continue resuscitation safely during the COVID-19 pandemic.[18] Since publication of these initial guidelines, reports from across Europe[50–61] have highlighted the impact of COVID-19 on the epidemiology and outcomes from cardiac arrest.

Impact of COVID-19 on cardiac arrest

A systematic review, summarising information from 10 studies (with 35,379 participants) reported an increase in the incidence, with out of hospital cardiac arrest during the initial COVID-19 wave.[62] There was significant clinical and statistical heterogeneity in the studies contained in the systematic review, hence a narrative synthesis is presented here. The patterns of presentation of cardiac arrest changed during the COVID-19 period with an increase in medical causes of cardiac arrest (4 of 5 studies) and reduction in trauma-related cardiac arrest (4 of 5 studies). More cardiac arrests occurred at home, with a variable impact on whether arrests were witnessed or not. The rate of bystander CPR varied between studies (6 studies reported lower rates of bystander CPR, 4 reported higher rates of bystander CPR). Ambulance response times increased and fewer resuscitation attempts were initiated or continued by ambulance crews. The proportion of patients with shockable rhythms decreased as did the use of automated external defibrillators. The use of supraglottic airways increased and rate of intubation decreased. Overall the rates of return of spontaneous circulation, admission to hospital and survival to discharge all decreased.[62,63]

The changes in the epidemiology, treatment and outcomes of cardiac arrest during COVID-19 is likely to be due to a combination of direct effects and indirect effects as summarised in Fig. 2.[64,65]

Data from in-hospital cardiac arrest associated with COVID-19 are less widely reported. A multi-centre cohort study from 68 intensive care units in the United states reported that 701 of 5019 (14%) sustained an in-hospital cardiac arrest, amongst whom 400/701 (57%) received CPR. Seven percent (28/400) survived to hospital discharge with normal or mildly impaired neurological status.[66] In Wuhan, China, amongst 136 patients who sustained a cardiac arrest (83% on a ward), 4 (2.9%) survived to 30 days of whom 1 had a favourable neurological outcome.[67] It is clear that across the out-of-hospital and in-hospital settings that COVID-19 has had a significant impact on the epidemiology and outcome from cardiac arrest.

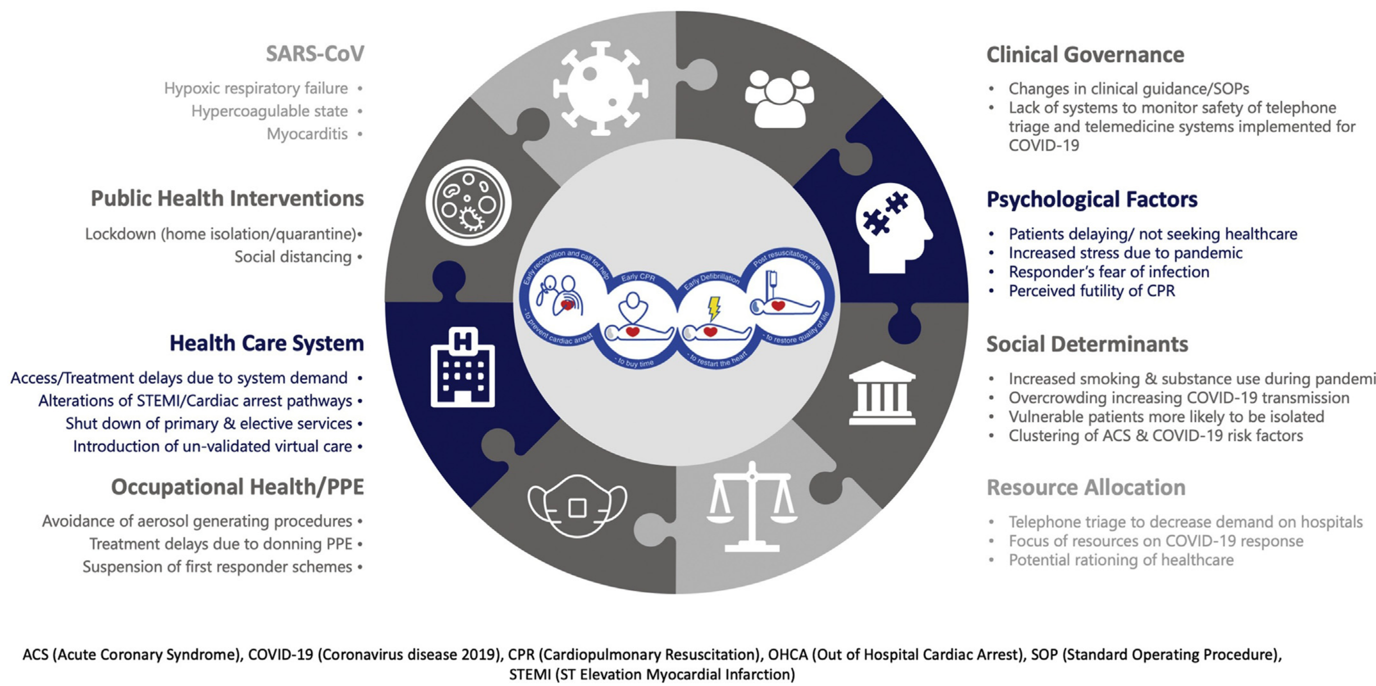

Fig. 2 – Systems level factors related to OHCA incidence and mortality during the COVID-19 pandemic (Reproduced from Christian and Couper[64]).

ERC COVID-19 guidelines

The ERC guidelines were based on the ILCOR systematic review on COVID-19 and CPR[68] and corresponding CoSTR.[69] Since publication of these reviews, the search strategies have been re-run and a further four articles identified.[70–74] None of the new articles contained information sufficient to change the previous treatment recommendations.

The ERC COVID-19 guidelines promote the continuation of resuscitation attempts for both out-of-hospital and in-hospital cardiac arrest, whilst seeking to reduce the risk to the person(s) providing treatment. The COVID-19 guidelines focus specifically on patients with suspected or confirmed COVID-19. If there is uncertainty about the presence of COVID-19, those providing treatment should undertake a dynamic risk assessment which may consider current COVID-19 prevalence, the patient's presentation (e.g. history of COVID-19 contact, COVID-19 symptoms), likelihood that treatment will be effective, availability of personal protective equipment (PPE) and personal risks for those providing treatment.[18]

The COVID-19 guidelines will be kept under continuous review and updated on-line as new evidence emerges. The main ERC Guidelines address resuscitation of those who are low risk or confirmed negative for COVID-19.

Concise guidelines for clinical practice

Epidemiology

In this section of the European Resuscitation Council Guidelines 2021, key information on the epidemiology and outcome of in and out of hospital cardiac arrest are presented. Key contributions from the European Registry of Cardiac Arrest (EuReCa) collaboration are highlighted. Recommendations are presented to enable health systems to develop registries as a platform for quality improvement and to inform health system planning and responses to cardiac arrest. Key messages from this section are presented in Fig. 3.

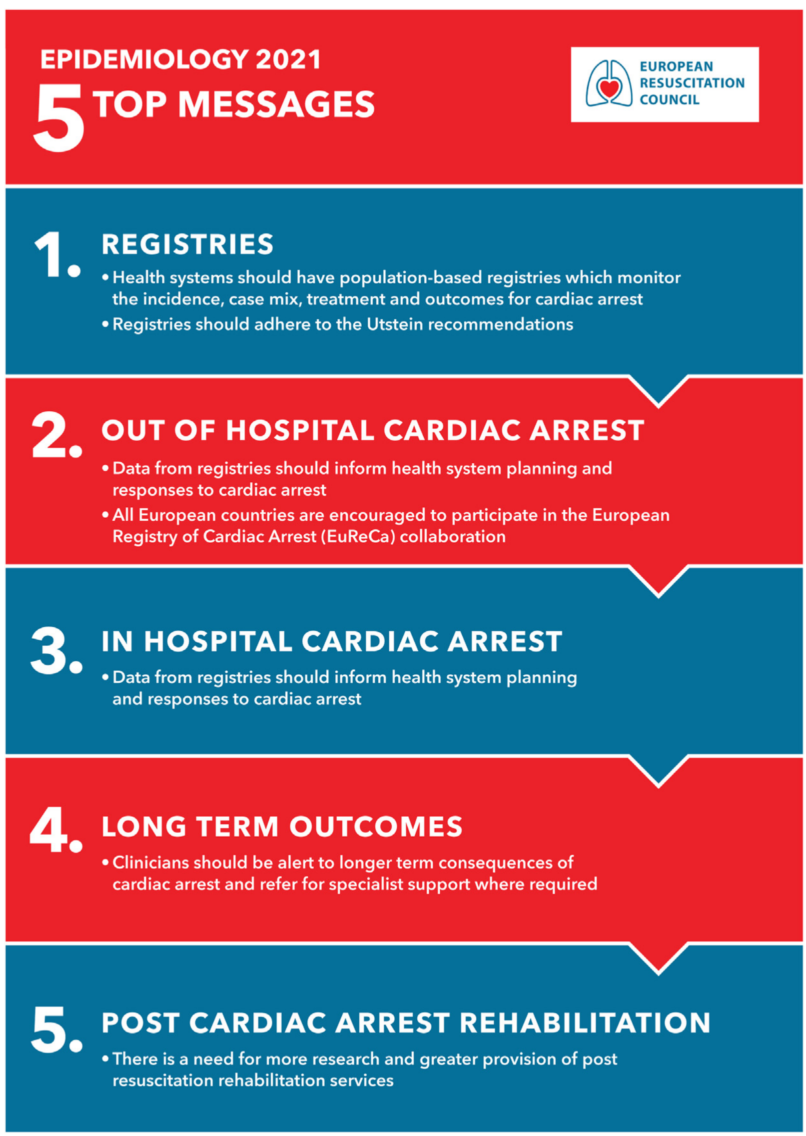

Fig. 3 – Epidemiology infographic summary.

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Out of hospital cardiac arrest

- Twenty-nine countries participated in the European Registry of Cardiac Arrest (EuReCa) collaboration.
- Out of hospital cardiac arrest registries exist in approximately 70% of European countries but the completeness of data captures varies widely.
- The annual incidence of OHCA in Europe is between 67 to 170 per 100,000 inhabitants.
- Resuscitation is attempted or continued by EMS personnel in about 50−60% of cases (between 19 to 97 per 100,000 inhabitants).
- The rate of bystander CPR varies between and within countries (average 58%, range 13% to 83%).
- The use of automated external defibrillators (AEDs) remains low in Europe (average 28%, range 3.8% to 59%).
- 80% of European countries provide dispatch assisted CPR and 75% have an AED registry. Most (90%) countries have access to cardiac arrest centres for post resuscitation care.
- Survival rates at hospital discharge are on average 8%, varying from 0% to 18%.
- Differences in EMS systems in Europe account for at least some of the differences observed in OHCA incidence and survival rates.

In hospital cardiac arrest

- The annual incidence of IHCA in Europe is between 1.5 and 2.8 per 1000 hospital admissions.
- Factors associated with survival are the initial rhythm, the place of arrest and the degree of monitoring at the time of collapse.
- Survival rates at 30 days/hospital discharge range from 15% to 34%.

Long term outcomes

- In European countries where withdrawal of life sustaining treatment (WLST) is routinely practiced, a good neurological outcome is seen in >90% of patients. Most patients are able to return to work.
- In countries where WLST is not practiced, poor neurological outcomes are more common (50%, 33% in a persistent vegetative state).
- Amongst survivors with a good neurological outcome, neurocognitive, fatigue and emotional problems are common and cause reduced health related quality of life.
- Patients and relatives may develop post-traumatic stress disorder.

Post cardiac arrest rehabilitation

- There is wide variation in the provision of rehabilitation services following cardiac arrest
- Many patients do not have access to post cardiac arrest rehabilitation

Key recommendations (expert consensus)

- Health systems should have population-based registries which monitor the incidence, case mix, treatment and outcomes for cardiac arrest
- Registries should adhere to the Utstein recommendations for data definitions and outcome reporting
- Data from registries should inform health system planning and responses to cardiac arrest.
- European countries are encouraged to participate in the EuReCa collaboration to enhance understanding of epidemiology and outcomes of cardiac arrest in Europe.
- There is a need for more research and greater provision of post resuscitation rehabilitation services
- It is expected that the clinical role of genetic and epigenetic factors will be increasingly understood as research in this area continues to grow. There are currently no specific resuscitation recommendations for patients with known genomic predispositions.

Systems saving lives

The European Resuscitation Council has produced these Systems Saving Lives guidelines, which are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. The topics covered include chain of survival, measuring performance of resuscitation, social media and smartphones apps for engaging community, European Restart a Heart Day, World Restart a Heart, KIDS SAVE LIVES campaign, lower-resource setting, European Resuscitation Academy and Global Resuscitation Alliance, early warning scores, rapid response systems, and medical emergency team, cardiac arrest centres and role of dispatcher. Key messages from this section are presented in Fig. 4.

Chain of survival & the formula of survival

- The actions linking the victim of sudden cardiac arrest with survival are called the chain of survival.
- The goal of saving more lives relies not only on solid and high-quality science but also effective education of lay people and healthcare professionals.
- Systems engaged in the care of cardiac arrest victims should be able to implement resource efficient systems that can improve survival after cardiac arrest.

Measuring the performance of resuscitation systems

- Organisations or communities that treat cardiac arrest should evaluate their system performance and target key areas with the goal to improve performance.

Social media and smartphones apps for engaging the community

- First responders (trained and untrained laypersons, firefighters, police officers, and off-duty healthcare professionals) who are near a suspected OHCA should be notified by the dispatch centre through an alerting system implemented with a smartphone app or a text message.
- Every European country is highly encouraged to implement such technologies in order to:
  - Improve the rate of bystander-initiated cardiopulmonary resuscitation (CPR).
  - Reduce the time to first compression and shock delivery.
  - Improve survival with good neurological recovery.

European Restart a Heart Day (ERHD) & World Restart a Heart (WRAH)

- National resuscitation councils, national governments and local authorities should
  - Engage with WRAH.
  - Raise awareness of the importance of bystander CPR and AEDs.
  - Train as many citizens as possible.
  - Develop new and innovative systems and policies that will save more lives.

Fig. 4 – System saving lives infographic summary.

KIDS SAVE LIVES

- All schoolchildren should routinely receive CPR training each year.
- Teach CHECK – CALL – COMPRESS.
- Trained schoolchildren should be encouraged to train family members and friends. The homework for all children after such training should be: "please train 10 other people within the next two weeks and report back".
- CPR training should also be delivered in higher education institutions, in particular to teaching and healthcare students.
- The responsible people in the Ministries of Education and/or Ministries of Schools and other leading politicians of each country should implement a nationwide programme for teaching CPR to schoolchildren. Training schoolchildren in CPR should be mandatory by law all over Europe and elsewhere.

Community initiatives to promote CPR implementation

- Healthcare systems should implement community initiatives for CPR training for large portions of the population (neighbourhood, town, region, a part of or a whole nation)

Low-resource settings

Resuscitation research in low-resource settings

- Research is required to understand different populations, aetiologies and outcome data of cardiac arrest in low-resource settings. Research should follow Utstein guidelines.
- The level of income of countries should be included in reports. A useful system to report level of income is the definition of the World Bank (gross national income per capita).
- When reporting about resuscitation systems and outcome, psychological and sociocultural views on cardiac arrest should be documented.
- Experts from all resource backgrounds should be consulted concerning local acceptability and applicability of international guidelines and recommendations for resuscitation.

Essential resources for resuscitation care systems in low-resource settings

- A list with essential resuscitation care resources that is specially adapted to low resource settings should be developed

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in collaboration with stakeholders from these low resource settings.

European Resuscitation Academy and Global Resuscitation Alliance

- Programmes such as the European Resuscitation Academy programmes should be implemented to increase bystander CPR rates and improve survival in case of OHCA.

Role of dispatcher

Dispatch-assisted recognition of cardiac arrest

- Dispatch centres should implement standardised criteria and algorithms to determine if a patient is in cardiac arrest at the time of the emergency call.
- Dispatch centres should monitor and track their ability to recognise cardiac arrest and continuously look for ways to improve recognition of cardiac arrest.

Dispatch-assisted CPR

- Dispatch centres should have systems in place to make sure call handlers provide CPR instructions for unresponsive persons not breathing normally.

Dispatch-assisted chest compression-only compared with standard CPR

- Dispatchers should provide chest compression – only CPR instructions for callers who identify unresponsive adult persons not breathing normally.

Early warning scores, rapid response systems, and medical emergency teams

- Consider the introduction of rapid response systems to reduce the incidence of in-hospital cardiac arrest and in-hospital mortality.

Cardiac arrest centres

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols.

Adult basic life support

The European Resuscitation Council has produced these basic life support guidelines, which are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. The topics covered include cardiac arrest recognition, alerting emergency services, chest compressions, rescue breaths, automated external defibrillation, CPR quality measurement, new technologies, safety, and foreign body airway obstruction.

The BLS writing group prioritised consistency with previous guidelines[75] to build confidence and encourage more people to act when a cardiac arrest occurs. Failing to recognise cardiac arrest remains a barrier to saving more lives. The terminology used in the ILCOR CoSTR,[76] is to start CPR in any person who is "unresponsive with absent or abnormal breathing". This terminology has been included in the BLS 2021 guidelines. Those learning or providing CPR are reminded that slow, laboured breathing (agonal breathing) should be considered a sign of cardiac arrest. The recovery position is included in the first aid section of the ERC guidelines 2021.[41] The first aid guidelines highlight that the recovery position should only be used for adults and children with a decreased level of responsiveness due to medical illness or non-physical trauma. The guidelines emphasise that is should only be used in people who do NOT meet the criteria for the initiation of rescue breathing or chest compressions (CPR). Anyone placed in the recovery position should have their breathing continuously monitored. If at any point their breathing becomes absent or abnormal, roll them on to their back and start chest compressions. Finally, the evidence informing the treatment of foreign body airway obstruction has been comprehensively updated, but the treatment algorithms remain the same.

Key messages from this section are presented in Fig. 5 and the BLS algorithm is depicted in Fig. 6.

How to recognise cardiac arrest

- Start CPR in any unresponsive person with absent or abnormal breathing.
- Slow, laboured breathing (agonal breathing) should be considered a sign of cardiac arrest.
- A short period of seizure-like movements can occur at the start of cardiac arrest. Assess the person after the seizure has stopped: if unresponsive and with absent or abnormal breathing, start CPR.

How to alert the emergency services

- Alert the emergency medical services (EMS) immediately if a person is unconscious with absent or abnormal breathing.
- A lone bystander with a mobile phone should dial the EMS number, activate the speaker or another hands-free option on the mobile phone and immediately start CPR assisted by the dispatcher.
- If you are a lone rescuer and you have to leave a victim to alert the EMS, activate the EMS first and then start CPR.

High quality chest compressions

- Start chest compressions as soon as possible.
- Deliver compressions on the lower half of the sternum ('in the centre of the chest').
- Compress to a depth of at least 5 cm but not more than 6 cm.
- Compress the chest at a rate of 100–120 min^{-1} with as few interruptions as possible.
- Allow the chest to recoil completely after each compression; do not lean on the chest.
- Perform chest compressions on a firm surface whenever feasible.

Rescue breaths

- Alternate between providing 30 compressions and 2 rescue breaths.
- If you are unable to provide ventilations, give continuous chest compressions.

AED

How to find an AED

- The location of an AED should be indicated by clear signage.

When and how to use an AED

- As soon as the AED arrives, or if one is already available at the site of the cardiac arrest, switch it on.
- Attach the electrode pads to the victim's bare chest according to the position shown on the AED or on the pads.
- If more than one rescuer is present, continue CPR whilst the pads are being attached.

Fig. 5 – BLS infographic summary.

- Follow the spoken (and/or visual) prompts from the AED.
- Ensure that nobody is touching the victim whilst the AED is analysing the heart rhythm.
- If a shock is indicated, ensure that nobody is touching the victim. Push the shock button as prompted. Immediately restart CPR with 30 compressions.
- If no shock is indicated, immediately restart CPR with 30 compressions.
- In either case, continue with CPR as prompted by the AED. There will be a period of CPR (commonly 2 min) before the AED prompts for a further pause in CPR for rhythm analysis.

Compressions before defibrillation

- Continue CPR until an AED (or other defibrillator) arrives on site and is switched on and attached to the victim.
- Do not delay defibrillation to provide additional CPR once the defibrillator is ready.

Fully automatic AEDs

- If a shock is indicated, fully automatic AEDs are designed to deliver a shock without any further action by the rescuer. The safety of fully automatic AEDs have not been well studied.

Safety of AEDs

- Many studies of public access defibrillation have shown that AEDs can be used safely by bystanders and first responders. Although injury to the CPR provider from a shock by a defibrillator is extremely rare, do not continue chest compression during shock delivery.

Safety

- Make sure you, the victim and any bystanders are safe.
- Laypeople should initiate CPR for presumed cardiac arrest without concerns of harm to victims not in cardiac arrest.

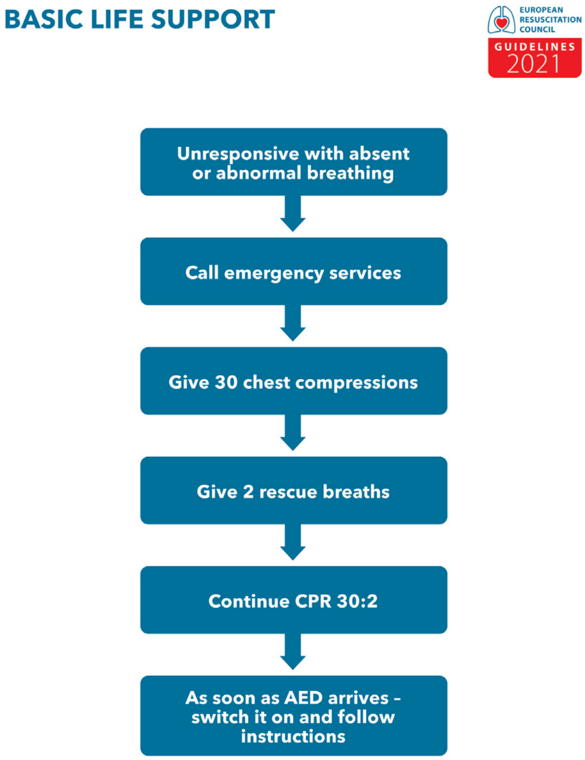

Fig. 6 – BLS algorithm.

- Lay people may safely perform chest compressions and use an AED as the risk of infection during compressions and harm from accidental shock during AED use is very low.
- Separate guidelines have been developed for resuscitation of victims with suspected or confirmed acute respiratory syndrome coronavirus 2 (SARS-CoV-2). See www.erc.edu/covid

How technology can help

- EMS systems should consider the use of technology such as smartphones, video communication, artificial intelligence and drones to assist in recognising cardiac arrest, to dispatch first responders, to communicate with bystanders to provide dispatcher-assisted CPR and to deliver AEDs to the site of cardiac arrest.

Foreign body airway obstruction

- Suspect choking if someone is suddenly unable to speak or talk, particularly if eating.
- Encourage the victim to cough.
- If the cough becomes ineffective, give up to 5 back blows:
  - Lean the victim forwards.
  - Apply blows between the shoulder blades using the heel of one hand
- If back blows are ineffective, give up to 5 abdominal thrusts:
  - Stand behind the victim and put both your arms around the upper part of the victim's abdomen.
  - Lean the victim forwards.
  - Clench your fist and place it between the umbilicus (navel) and the ribcage.
  - Grasp your fist with the other hand and pull sharply inwards and upwards.
- If choking has not been relieved after 5 abdominal thrusts, continue alternating 5 back blows with 5 abdominal thrusts until it is relieved, or the victim becomes unconscious.
- If the victim becomes unconscious, start CPR

Adult advanced life support

These European Resuscitation Council Advanced Life Support (ALS) guidelines, are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. This section provides guidelines on the prevention of and ALS treatments for both in-hospital cardiac arrest and out-of-hospital cardiac arrest.

There are no major changes in the 2021 Adult ALS Guidelines. There is a greater recognition that patients with both in- and out-of-hospital cardiac arrest have premonitory signs, and that many of these arrests may be preventable. High quality chest compressions with minimal interruption and early defibrillation remain priorities. During CPR, start with basic airway techniques and progress stepwise according to the skills of the rescuer until effective ventilation is achieved. If an advanced airway is required, only rescuers with a high tracheal intubation success rate should use tracheal intubation. The expert consensus is that a high success rate is over 95% within two attempts at intubation. When adrenaline is used it should be used as soon as possible when the cardiac arrest rhythm is non-shockable cardiac arrest, and after 3 defibrillation attempts for a shockable cardiac arrest rhythm. The guideline recognises the increasing role of point-of-care ultrasound (POCUS) in peri-arrest care for diagnosis, but emphasise that it requires a skilled operator, and the need to minimise interruptions during chest compression. The guideline reflects the increasing evidence for extracorporeal CPR (eCPR) as a rescue therapy for selected patients with cardiac arrest when conventional ALS measures are failing or to facilitate specific interventions (e.g. coronary angiography and percutaneous coronary intervention (PCI), pulmonary thrombectomy for massive pulmonary embolism, rewarming after hypothermic cardiac arrest) in settings in which it can be implemented. These ERC guidelines have followed European and international guidelines for the treatment of peri-arrest arrhythmias.

Key messages from this section are presented in Fig. 7 and the ALS algorithm is depicted in Fig. 8.

Prevention of in-hospital cardiac arrest

- The ERC supports shared decision making and advanced care planning which integrates resuscitation decisions with emergency care treatment plans to increase clarity of treatment goals and also prevent inadvertent deprivation of other indicated treatments, besides CPR. These plans should be recorded in a consistent manner (See Ethics section 11).[44]
- Hospitals should use a track and trigger early warning score system for the early identification of patients who are critically ill or at risk of clinical deterioration.
- Hospitals should train staff in the recognition, monitoring and immediate care of the acutely-ill patient.
- Hospitals should empower all staff to call for help when they identify a patient at risk of physiological deterioration. This includes calls based on clinical concern, rather than solely on vital signs.
- Hospitals should have a clear policy for the clinical response to abnormal vital signs and critical illness. This may include a critical care outreach service and, or emergency team (e.g. medical emergency team, rapid response team).

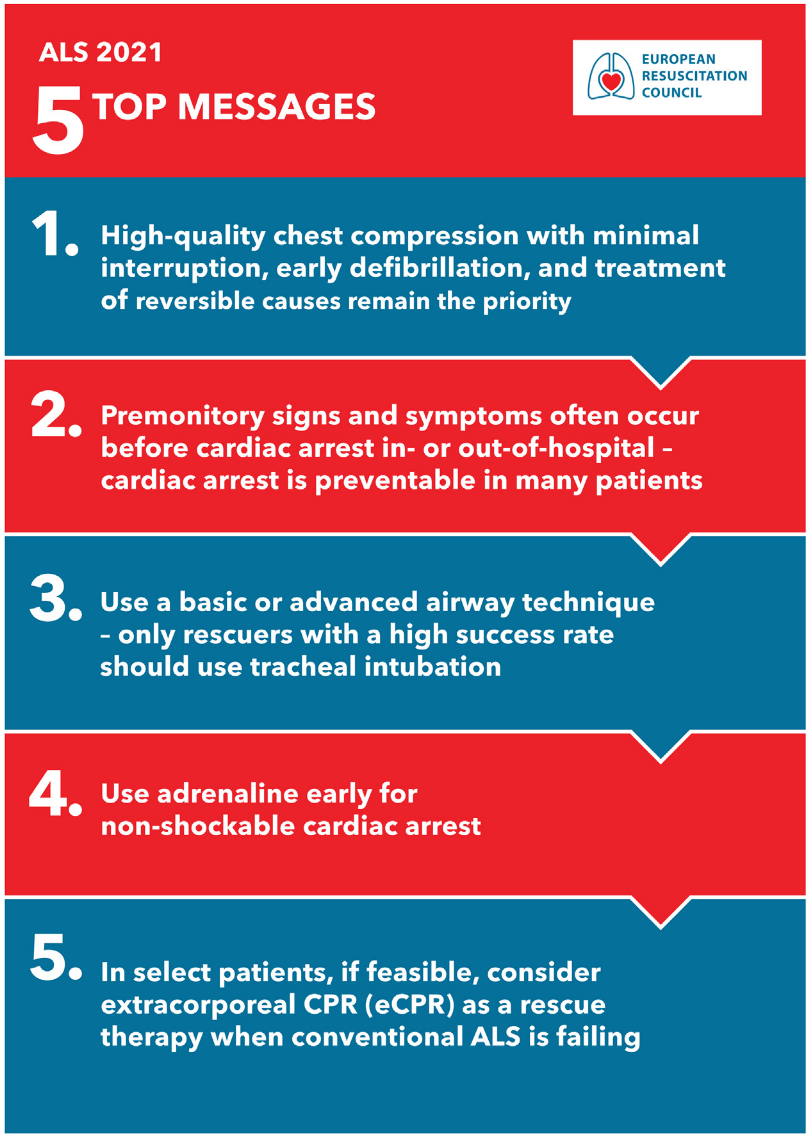

Fig. 7 – ALS infographic summary.

- Hospital staff should use structured communication tools to ensure effective handover of information.
- Patients should receive care in a clinical area that has the appropriate staffing, skills, and facilities for their severity of illness.
- Hospitals should review cardiac arrest events to identify opportunities for system improvement and share key learning points with hospital staff.

Prevention of out-of-hospital cardiac arrest

- Symptoms such as syncope (especially during exercise, while sitting or supine), palpitations, dizziness and sudden shortness of breath that are consistent with an arrhythmia should be investigated.
- Apparently healthy young adults who suffer sudden cardiac death (SCD) can also have signs and symptoms (e.g. syncope/pre-syncope, chest pain and palpitations) that should alert healthcare professionals to seek expert help to prevent cardiac arrest.
- Young adults presenting with characteristic symptoms of arrhythmic syncope should have a specialist cardiology assessment, which should include an electrocardiogram (ECG) and in most cases echocardiography and an exercise test.
- Systematic evaluation in a clinic specialising in the care of those at risk for SCD is recommended in family members of young victims of SCD or those with a known cardiac disorder resulting in an increased risk of SCD.
- Identification of individuals with inherited conditions and screening of family members can help prevent deaths in young people with inherited heart disorders.
- Follow current European Society of Cardiology (ESC) guidelines for the diagnosis and management of syncope.

Treatment of in-hospital cardiac arrest

- Hospital systems should aim to recognise cardiac arrest, start CPR immediately, and defibrillate rapidly (<3 min) when appropriate.
- All hospital staff should be able to rapidly recognise cardiac arrest, call for help, start CPR and defibrillate (attach an AED and follow the AED prompts, or use a manual defibrillator).

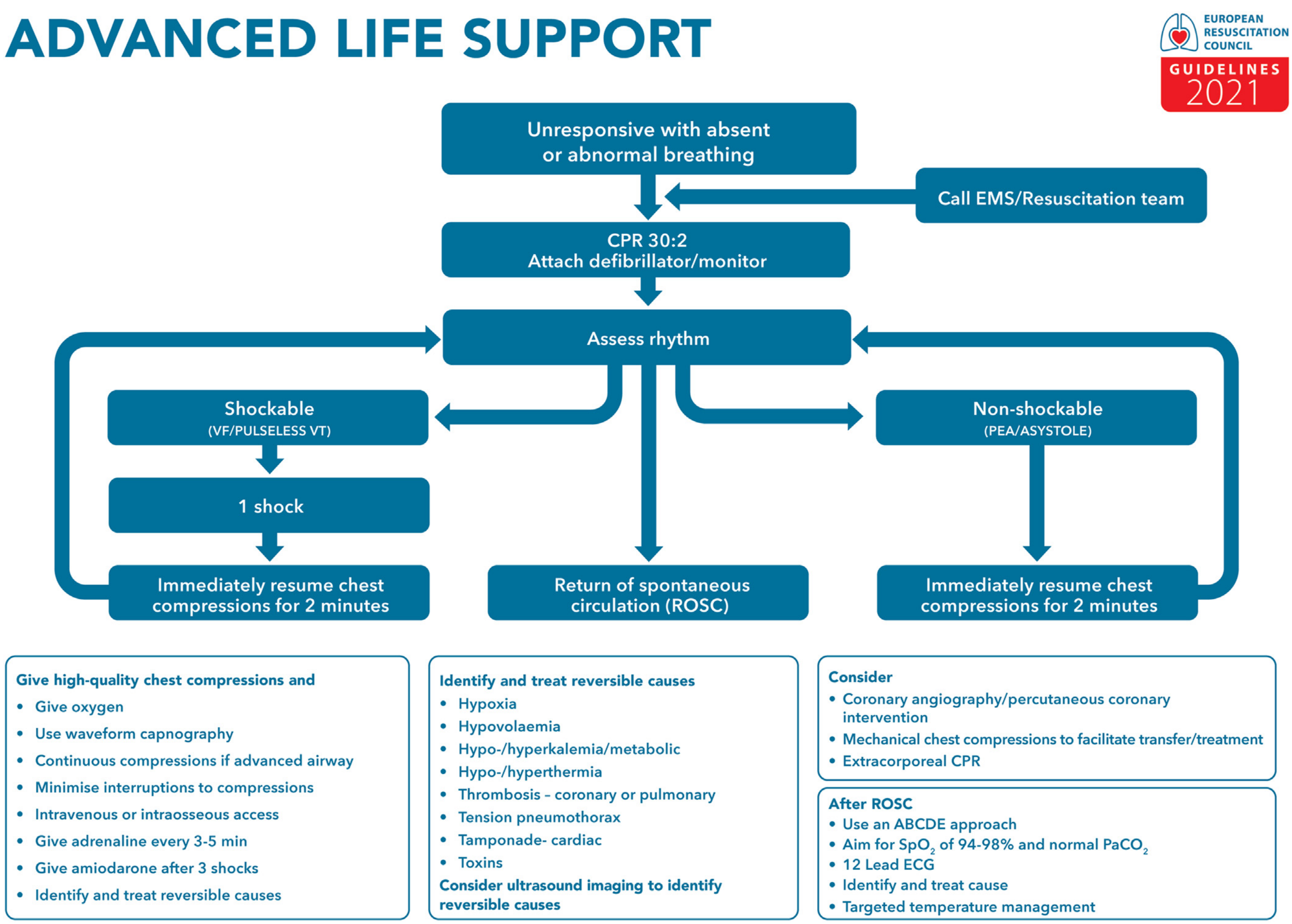

Fig. 8 – ALS algorithm.

- European hospitals should adopt a standard "Cardiac Arrest Call" telephone number (2222).
- Hospitals should have a resuscitation team that immediately responds to IHCAs.
- The hospital resuscitation team should include team members who have completed an accredited adult ALS course.
- Resuscitation team members should have the key skills and knowledge to manage a cardiac arrest including manual defibrillation, advanced airway management, intravenous access, intra-osseous access, and identification and treatment of reversible causes.
- The resuscitation team should meet at the beginning of each shift for introductions and allocation of team roles.
- Hospitals should standardise resuscitation equipment.

ALS considerations for out-of-hospital cardiac arrest

- Start ALS as early as possible.
- Emergency medical systems (EMS) should consider implementing criteria for the withholding and termination of resuscitation (TOR) taking in to consideration specific local legal, organisational and cultural context (see section 11 Ethics).[44]
- Systems should define criteria for the withholding and termination of CPR, and ensure criteria are validated locally (see section 11 Ethics).[44]
- Emergency medical systems (EMS) should monitor staff exposure to resuscitation and low exposure should be addressed to increase EMS team experience in resuscitation.
- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols (see Systems saving lives – Section 4).[36]

Manual defibrillation

Defibrillation strategy

- Continue CPR while a defibrillator is retrieved and pads applied.
- Give a shock as early as possible when appropriate.
- Deliver shocks with minimal interruption to chest compression, and minimise the pre-shock and post-shock pause. This is achieved by continuing chest compressions during defibrillator charging, delivering defibrillation with an interruption in chest compressions of less than 5 s and then immediately resuming chest compressions.
- Immediately resume chest compressions after shock delivery. If there is a combination of clinical and physiological signs of return of spontaneous circulation (ROSC) such as waking, purposeful movement, arterial waveform or a sharp rise in end-tidal carbon dioxide ($ETCO_2$), consider stopping chest compressions for rhythm analysis, and if appropriate a pulse check.

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Safe and effective defibrillation

- Minimise the risk of fire by taking off any oxygen mask or nasal cannulae and place them at least 1 m away from the patient's chest. Ventilator circuits should remain attached.
- Antero-lateral pad position is the position of choice for initial pad placement. Ensure that the apical (lateral) pad is positioned correctly (mid-axillary line, level with the V6 pad position) i.e. below the armpit.
- In patients with an implantable device, place the pad >8 cm away from the device, or use an alternative pad position. Also consider an alternate pad position when the patient is in the prone position (bi-axillary), or in a refractory shockable rhythm (see below).
- A shock can be safely delivered without interrupting mechanical chest compression.
- During manual chest compressions, 'hands-on' defibrillation, even when wearing clinical gloves, is a risk to the rescuer.

Energy levels and number of shocks

- Use single shocks where indicated, followed by a 2 min cycle of chest compressions.
- The use of up to three-stacked shocks may be considered only if initial ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) occurs during a witnessed, monitored cardiac arrest with a defibrillator immediately available e.g. during cardiac catheterisation or in a high dependency area.
- Defibrillation shock energy levels are unchanged from the 2015 guidelines:
  - For biphasic waveforms (rectilinear biphasic or biphasic truncated exponential), deliver the first shock with an energy of at least 150 J.
  - For pulsed biphasic waveforms, deliver the first shock at 120−150 J.
- If the rescuer is unaware of the recommended energy settings of the defibrillator, for an adult use the highest energy setting for all shocks.

Recurrent or refractory VF

- Consider escalating the shock energy, after a failed shock and for patients where refibrillation occurs.
- For refractory VF, consider using an alternative defibrillation pad position (e.g. anterior−posterior)
- Do not use dual (double) sequential defibrillation for refractory VF outside of a research setting.

Airway and ventilation

- During CPR, start with basic airway techniques and progress stepwise according to the skills of the rescuer until effective ventilation is achieved.
- If an advanced airway is required, only rescuers with a high tracheal intubation success rate should use tracheal intubation. The expert consensus is that a high success rate is over 95% within two attempts at intubation.
- Aim for less than a 5 s interruption in chest compression for tracheal intubation.
- Use direct or video laryngoscopy for tracheal intubation according to local protocols and rescuer experience
- Use waveform capnography to confirm tracheal tube position.
- Give the highest feasible inspired oxygen during CPR.
- Give each breath over 1 s to achieve a visible chest rise.
- Once a tracheal tube or a supraglottic airway (SGA) has been inserted, ventilate the lungs at a rate of 10 min^{-1} and continue chest compressions without pausing during ventilations. With a SGA, if gas leakage results in inadequate ventilation, pause compressions for ventilation using a compression-ventilation ratio of 30:2.

Drugs and fluids

Vascular access

- Attempt intravenous (IV) access first to enable drug delivery in adults in cardiac arrest.
- Consider intraosseous (IO) access if attempts at IV access are unsuccessful or IV access is not feasible.

Vasopressor drugs

- Give adrenaline 1 mg IV (IO) as soon as possible for adult patients in cardiac arrest with a non-shockable rhythm.
- Give adrenaline 1 mg IV (IO) after the 3rd shock for adult patients in cardiac arrest with a shockable rhythm.
- Repeat adrenaline 1 mg IV (IO) every 3−5 min whilst ALS continues.

Antiarrhythmic drugs

- Give amiodarone 300 mg IV(IO) for adult patients in cardiac arrest who are in VF/pVT after three shocks have been administered.
- Give a further dose of amiodarone 150 mg IV (IO) for adult patients in cardiac arrest who are in VF/pVT after five shocks have been administered.
- Lidocaine 100 mg IV (IO) may be used as an alternative if amiodarone is not available or a local decision has been made to use lidocaine instead of amiodarone. An additional bolus of lidocaine 50 mg can also be given after five defibrillation attempts.

Thrombolytic drugs

- Consider thrombolytic drug therapy when pulmonary embolus is the suspected or confirmed as the cause of cardiac arrest.
- Consider CPR for 60−90 min after administration of thrombolytic drugs.

Fluids

- Give IV (IO) fluids only where the cardiac arrest is caused by or possibly caused by hypovolaemia.

Waveform capnography during advanced life support

- Use waveform capnography to confirm correct tracheal tube placement during CPR.
- Use waveform capnography to monitor the quality of CPR.
- An increase in $ETCO_2$ during CPR may indicate that ROSC has occurred. However, chest compression should not be interrupted based on this sign alone.
- Although high and increasing $ETCO_2$ values are associated with increased rates of ROSC and survival after CPR, do not use a low $ETCO_2$ value alone to decide if a resuscitation attempt should be stopped.

Use of ultrasound imaging during advanced life support

- Only skilled operators should use intra-arrest point-of-care ultrasound (POCUS).
- POCUS must not cause additional or prolonged interruptions in chest compressions.

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- POCUS may be useful to diagnose treatable causes of cardiac arrest such as cardiac tamponade and pneumothorax.
- Right ventricular dilation in isolation during cardiac arrest should not be used to diagnose massive pulmonary embolism.
- Do not use POCUS for assessing contractility of the myocardium as a sole indicator for terminating CPR.

Mechanical chest compression devices

- Consider mechanical chest compressions only if high-quality manual chest compression is not practical or compromises provider safety.
- When a mechanical chest compression device is used, minimise interruptions to chest compression during device use by using only trained teams familiar with the device.

Extracorporeal CPR

- Consider extracorporeal CPR (eCPR) as a rescue therapy for selected patients with cardiac arrest when conventional ALS measures are failing or to facilitate specific interventions (e.g. coronary angiography and percutaneous coronary intervention (PCI), pulmonary thrombectomy for massive pulmonary embolism, rewarming after hypothermic cardiac arrest) in settings in which it can be implemented.

Peri-arrest arrhythmias

- The assessment and treatment of all arrhythmias addresses the condition of the patient (stable versus unstable) and the nature of the arrhythmia. Life-threatening features in an unstable patient include:
  - Shock – appreciated as hypotension (e.g. systolic blood pressure < 90 mmHg) and symptoms of increased sympathetic activity and reduced cerebral blood flow.
  - Syncope – as a consequence of reduced cerebral blood flow.
  - Heart failure – manifested by pulmonary oedema (failure of the left ventricle) and/or raised jugular venous pressure (failure of the right ventricle).
  - Myocardial ischaemia – may present with chest pain (angina) or may occur without pain as an isolated finding on the 12-lead ECG (silent ischaemia).

Tachycardias

- Electrical cardioversion is the preferred treatment for tachyarrhythmia in the unstable patient displaying potentially life-threatening adverse signs.
- Conscious patients require anaesthesia or sedation, before attempting synchronised cardioversion.
- To convert atrial or ventricular tachyarrhythmias, the shock must be synchronised to occur with the R wave of the electrocardiogram (ECG).
- For atrial fibrillation:
  - An initial synchronised shock at maximum defibrillator output rather than an escalating approach is a reasonable strategy based on current data.
- For atrial flutter and paroxysmal supraventricular tachycardia:
  - Give an initial shock of 70–120 J.
  - Give subsequent shocks using stepwise increases in energy.
- For ventricular tachycardia with a pulse:
  - Use energy levels of 120–150 J for the initial shock.
  - Consider stepwise increases if the first shock fails to achieve sinus rhythm.
- If cardioversion fails to restore sinus rhythm and the patient remains unstable, give amiodarone 300 mg intravenously over 10–20 min (or procainamide 10–15 mg/kg over 20 min) and re-attempt electrical cardioversion. The loading dose of amiodarone can be followed by an infusion of 900 mg over 24 h.
- If the patient with tachycardia is stable (no adverse signs or symptoms) and is not deteriorating, pharmacological treatment may be possible.
- Consider amiodarone for acute heart rate control in AF patients with haemodynamic instability and severely reduced left ventricular ejection fraction (LVEF). For patients with LVEF < 40% consider the smallest dose of beta-blocker to achieve a heart rate less than 110 min^{-1}. Add digoxin if necessary.

Bradycardia

- If bradycardia is accompanied by adverse signs, give atropine 500 μg IV (IO) and, if necessary, repeat every 3–5 min to a total of 3 mg.
- If treatment with atropine is ineffective, consider second line drugs. These include isoprenaline (5 $\mu g\ min^{-1}$ starting dose), and adrenaline (2–10 $\mu g\ min^{-1}$).
- For bradycardia caused by inferior myocardial infarction, cardiac transplant or spinal cord injury, consider giving aminophylline (100–200 mg slow intravenous injection).
- Consider giving glucagon if beta-blockers or calcium channel blockers are a potential cause of the bradycardia.
- Do not give atropine to patients with cardiac transplants – it can cause a high-degree AV block or even sinus arrest – use aminophylline.
- Consider pacing in patients who are unstable, with symptomatic bradycardia refractory to drug therapies.
- If transthoracic pacing is ineffective, consider transvenous pacing.
- Whenever a diagnosis of asystole is made, check the ECG carefully for the presence of P waves because unlike true asystole, this is more likely to respond to cardiac pacing.
- If atropine is ineffective and transcutaneous pacing is not immediately available, fist pacing can be attempted while waiting for pacing equipment.

Uncontrolled organ donation after circulatory death

- When there is no ROSC, consider uncontrolled organ donation after circulatory death in settings where there is an established programme, and in accordance with local protocols and legislation.

Debriefing

- Use data-driven, performance-focused debriefing of rescuers to improve CPR quality and patient outcomes.

Special circumstances

These European Resuscitation Council (ERC) Cardiac Arrest in Special Circumstances guidelines are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. This section provides guidelines on the modifications required to basic and advanced life support for the prevention and treatment of cardiac arrest in special circumstances; specifically special causes (hypoxia, trauma, anaphylaxis, sepsis, hypo/hyperkalaemia and other electrolyte disorders, hypothermia, avalanche, hyperthermia and malignant hyperthermia, pulmonary embolism, coronary thrombosis, cardiac tamponade, tension pneumothorax, toxic agents), special settings (operating room, cardiac surgery, catheter laboratory, dialysis unit, dental clinics, transportation (in-flight, cruise ships), sport, drowning, mass casualty incidents), and special patient groups (asthma and COPD, neurological disease, obesity, pregnancy).

There are no major changes in the 2021 adult Special Circumstances guidelines. There is greater emphasis on the priorisation of recognition and management for reversible causes in cardiac arrest due to special circumstances. The guidelines reflect the increasing evidence for extracorporeal CPR (eCPR) as management strategy for selected patients with cardiac arrest in settings in which it can be implemented. This ERC guideline follows European and international guidelines for treatment recommendations (electrolyte disorders, sepsis, coronary thrombosis, accidental hypothermia and avalanche rescue). The trauma section has been revised with additional measures for haemorrhage control, the toxic agents section comes with an extensive supplement, focusing on management of specific toxic agents. Prognostication of successful rewarming in hypothermic patients follows more differentiated scoring systems (HOPE score; ICE score). In avalanche rescue priority is given to ventilations as hypoxia is the most likely reason of cardiac arrest. Caused by the increasing number of patients from that special settings, recommendations for cardiac arrest in the catheterisation laboratory and in the dialysis unit have been added.

Key messages from this section are presented in Fig. 9.

Special causes

Hypoxia

- Follow the standard ALS algorithm when resuscitating patients with asphyxial cardiac arrest.
- Treat the cause of the asphyxia/hypoxaemia as the highest priority because this is a potentially reversible cause of the cardiac arrest.
- Effective ventilation with the highest feasible inspired oxygen is a priority in patients with asphyxial cardiac arrest.

Hypovolaemia

Traumatic cardiac arrest (TCA)

- Resuscitation in TCA should focus on the immediate, simultaneous treatment of reversible causes.
- The response to TCA is time critical and success depends on a well-established chain of survival, including focused pre-hospital and specialised trauma centre care.
- TCA (hypovolemic shock, obstructive shock, neurogenic shock) is different from cardiac arrest due to medical causes; this is reflected in the treatment algorithm (Figure Trauma1).
- Use ultrasound to identify the underlying cause of cardiac arrest and target resuscitative interventions.
- Treating reversible causes simultaneously takes priority over chest compressions. Chest compression must not delay treatment of reversible causes in TCA.
- Control haemorrhage with external pressure, haemostatic gauze, tourniquets and pelvic binder.
- 'Don't pump an empty heart'.
- Resuscitative thoracotomy (RT) has a role in TCA and traumatic peri-arrest.

Anaphylaxis

- Recognise anaphylaxis by the presence of airway (swelling), breathing (wheeze or persistent coughing), or circulation (hypotension) problems with or without skin and mucosal changes. This can be in the context of a known trigger in a patient with an allergy, or suspected anaphylaxis in a patient with no previous history of allergy.
- Call for help early.
- Remove or stop the trigger if feasible.
- Give intramuscular (IM) adrenaline (0.5 mg (which is 0.5 mL of a 1 mg in 1 mL ampoule of adrenaline)) into the anterolateral thigh as soon as anaphylaxis is suspected. Repeat the IM adrenaline if there is no improvement in the patient's condition after about 5 min.
- Ensure the patient is lying and do not suddenly sit or stand the patient up.
- Use an ABCDE approach and treat problems early (oxygen, fluids, monitoring).
- Give an IV crystalloid fluid bolus early and monitor the response – large volumes of fluids may be needed.
- Consider IV adrenaline as a bolus (20–50 mcg) or infusion for refractory anaphylaxis or in specialist care settings where the skills are available.
- Consider alternative vasopressors (vasopressin, noradrenaline, metaraminol, phenylephrine) in refractory anaphylaxis.
- Consider IV glucagon in patients taking beta-blockers.
- Start chest compressions and ALS as soon as cardiac arrest is suspected and follow standard guidelines.
- Consider ECLS or ECPR for patients who are peri-arrest or in cardiac arrest as a rescue therapy in those settings where it is feasible.
- Follow existing guidelines for the investigation and follow-up care of patients with suspected anaphylaxis and confirmed anaphylaxis.

Sepsis

Cardiac arrest prevention in sepsis

- Follow the Surviving Sepsis Guidelines Hour-1 bundle for the initial resuscitation of sepsis and septic shock
  Specifically:
- Measure lactate level.
- Obtain blood cultures prior to administration of antibiotics.
- Administer broad-spectrum antibiotics.
- Begin rapid administration of 30 ml/kg crystalloid for hypotension or a lactate $\geq$4 mmol L^{-1}.
- Apply vasopressors if the patient is hypotensive during or after fluid resuscitation to maintain mean arterial pressure $\geq$65 mmHg.

Cardiac arrest treatment due to sepsis

- Follow standard ALS guidelines including giving the maximal inspired oxygen concentration.
- Intubate the trachea if able to do so safely.
- Intravenous (IV) crystalloid fluid resuscitation with a 500 ml initial bolus. Consider administering further boluses.
- Venepuncture for venous blood gas/lactate/electrolytes.
- Control the source of sepsis, if feasible, and give antibiotics early.

Hypo-/hyperkalaemia and other electrolyte disorders

- Consider hyperkalaemia or hypokalaemia in all patients with an arrhythmia or cardiac arrest.
- Check for hyperkalaemia using point-of-care testing if available.
- The ECG may be the most readily available diagnostic tool.

Fig. 9 – Special circumstances infographic summary.

Treatment of hyperkalaemia

- Protect the heart.
- Shift potassium into cells.
- Remove potassium from the body.
  - Consider dialysis initiation during CPR for refractory hyperkalaemic cardiac arrest.
  - Consider ECPR.
- Monitor serum potassium and glucose levels.
- Prevent the recurrence of hyperkalaemia.

Patient not in cardiac arrest

- Use the ABCDE approach and correct any abnormalities, obtain IV access.
- Check serum K^+ level – use blood gas analyser if available and send a sample to the laboratory.
- Perform an ECG – look for signs of hyperkalaemia.
- Cardiac monitoring – if the serum $K^+ \geq 6.5$ mmol/l or if the patient is acutely unwell.

Follow hyperkalaemia algorithm guided by the severity of hyperkalaemia and ECG changes.

Moderate Hyperkalaemia (serum K^+ 6.0–6.4 mmol/l)

- Shift K^+ into cells: Give 10 units short-acting insulin and 25 g glucose (250 ml glucose 10%) IV over 15–30 min (onset in 15–30 min; maximal effect 30–60 min; duration of action 4–6 h; monitor blood glucose). Follow up with 10% glucose infusion at 50 ml/h for 5 h in patients with a pre-treatment blood glucose <7 mmol/l.
- Remove K^+ from the body: Consider oral administration of a potassium binder, e.g. Sodium Zirconium Cyclosilicate (SZC), or a cation exchange resin e.g., Patiromer or calcium resonium according to local practice.

Severe Hyperkalaemia (serum $K^+ \geq 6.5$ mmol/l) without ECG changes

- Seek expert help early.
- Shift K^+ into cells: Give insulin/glucose infusion (as above).
- Shift K^+ into cells: Give salbutamol 10–20 mg nebulised (onset 15–30 min; duration of action 4–6 h).

- Remove K^+ from the body: Give SZC (onset in 60 min) or Patiromer (onset in 4–7 h) and consider dialysis.

Severe Hyperkalaemia (serum K^+ ≥6.5 mmol/l) with toxic ECG changes

- Seek expert help early.
- Protect the heart: Give 10 ml calcium chloride 10% IV over 2–5 min (onset 1–3 min, repeat ECG, further dose if toxic ECG changes persist).
- Shift K^+ into cells: Give insulin/glucose infusion (as above).
- Shift K^+ into cells: Give salbutamol 10–20 mg nebulised (as above).
- Remove K^+ from the body: Give SZC or Patiromer (see above) and consider dialysis at outset or if refractory to medical treatment.

Patient in cardiac arrest

- Confirm hyperkalaemia using blood gas analyser if available.
- Protect the heart: Give 10 ml calcium chloride 10% IV by rapid bolus injection. Consider repeating dose if cardiac arrest is refractory or prolonged.
- Shift K^+ into cells: Give 10 units soluble insulin and 25 g glucose IV by rapid injection. Monitor blood glucose. Administer 10% glucose infusion guided by blood glucose to avoid hypoglycaemia.
- Shift K^+ into cells: Give 50 mmol sodium bicarbonate (50 ml 8.4% solution) IV by rapid injection.
- Remove K^+ from the body: Consider dialysis for refractory hyperkalaemic cardiac arrest.
- Consider the use of a mechanical chest compression device if prolonged CPR is needed.
- Consider ECLS or ECPR for patients who are peri-arrest or in cardiac arrest as a rescue therapy in those settings where it is feasible.

Treatment of hypokalaemia

- Restore potassium level (rate and route of replacement guided by clinical urgency).
- Check for any potential exacerbating factors (e.g. digoxin toxicity, hypomagnesaemia).
- Monitor serum K+ (adjust replacement as needed depending on level).
- Prevent recurrence (assess and remove cause).

Hypothermia

Accidental hypothermia

- Assess core temperature with a low reading thermometer, tympanic in spontaneously breathing, oesophageal in patients with a tracheal tube or a supraglottic device with an oesophageal channel in place.
- Check for the presence of vital signs for up to 1 min.
- Prehospital insulation, triage, fast transfer to a hospital and rewarming are key interventions.
- Hypothermic patients with risk factors for imminent cardiac arrest (i.e., core temperature <30 °C, ventricular arrhythmia, systolic blood pressure <90 mmHg) and those in cardiac arrest should ideally be directly transferred to an extracorporeal life support (ECLS) centre for rewarming.
- Hypothermic cardiac arrest patients should receive continuous CPR during transfer.
- Chest compression and ventilation rate should not be different to CPR in normothermic patients.
- If ventricular fibrillation (VF) persists after three shocks, delay further attempts until the core temperature is >30 °C.
- Withhold adrenaline if the core temperature is <30 °C.
- Increase administration intervals for adrenaline to 6–10 min if the core temperature is >30 °C.
- If prolonged transport is required or the terrain is difficult, use of a mechanical CPR device is recommended.
- In hypothermic arrested patients <28 °C delayed CPR may be used when CPR on site is too dangerous or not feasible, intermittent CPR can be used when continuous CPR is not possible.
- In-hospital prognostication of successful rewarming should be based on the HOPE or ICE score. The traditional in-hospital serum potassium prognostication is less reliable.
- In hypothermic cardiac arrest rewarming should be performed with ECLS, preferably with extra-corporeal membrane oxygenation (ECMO) over cardiopulmonary bypass (CPB).
- Non-ECLS rewarming should be initiated in a peripheral hospital if an ECLS centre cannot be reached within hours (e.g. 6 h).

Avalanche rescue

- Start with five ventilations in cardiac arrest, as hypoxia is the most likely cause of cardiac arrest.
- Perform standard ALS if burial time is <60 min.
- Provide full resuscitative measures, including ECLS rewarming, for avalanche victims with duration of burial >60 min without evidence of an obstructed airway or additional un-survivable injuries.
- Consider CPR to be futile in cardiac arrest with a burial time >60 min and additional evidence of an obstructed airway.
- In-hospital prognostication of successful rewarming should be based on the HOPE score. The traditional triage with serum potassium and core temperature (cut-offs 7 mmol/L and 30 °C, respectively) are less reliable.

Hyperthermia and malignant hyperthermia

Hyperthermia

- Measurement of core temperature should be available to guide treatment.
- Heat syncope – remove patient to a cool environment, cool passively and provide oral isotonic or hypertonic fluids.
- Heat exhaustion – remove patient to a cool environment, lie them flat, administer IV isotonic or hypertonic fluids, consider additional electrolyte replacement therapy with isotonic fluids. Replacement of 1–2 L crystalloids at 500 mL/h is often adequate.
- Simple external cooling measures are usually not required but may involve conductive, convective and evaporative measures (See section 10 First Aid).
- Heat stroke – a ‘cool and run’ approach is recommended:
  - Remove patient to a cool environment.
  - Lie them flat.
  - Immediately active cool using whole body (from neck down) water immersion technique (1–26 °C) until core temperature <39 °C.
  - Where water immersion is not available use immediately any active or passive technique that provides the most rapid rate of cooling.
  - Administer IV isotonic or hypertonic fluids (with blood sodium ≤ 130 mmol/L up to 3 × 100 mL NaCl 3%).

- Consider additional electrolyte replacement with isotonic fluids. Substantial amounts of fluids may be required.
- In exertional heat stroke a cooling rate faster than 0.10 °C/min is safe and desirable.
- Follow the ABCDE approach in any patient with deteriorating vital signs.

Malignant Hyperthermia

- Stop triggering agents immediately.
- Provide oxygen.
- Aim for normocapnia using hyperventilation.
- Consider correction of severe acidosis with bicarbonate (1−2 mmol kg^{-1}).
- Treat hyperkalaemia (calcium, glucose/insulin, hyperventilation) (see hyperkalaemia guideline).
- Give dantrolene (2.5 mg/kg initially, and 10 mg/kg as required).
- Start active cooling.
- Follow the ALS algorithm in cardiac arrest and continue cooling.
- After return of spontaneous circulation (ROSC) monitor the patient closely for 48−72 h, as 25% of patients experience relapse.
- Contact an expert malignant hyperthermia centre for advice and follow-up.

Thrombosis

Pulmonary Embolism

Cardiac arrest prevention

- Follow the ABCDE approach

Airway

- Treat life-threatening hypoxia with high-flow oxygen.

Breathing

- Consider pulmonary embolism (PE) in all patients with sudden onset of progressive dyspnoea and absence of known pulmonary disease (always exclude pneumothorax and anaphylaxis).

Circulation

- Obtain 12-lead ECG (exclude acute coronary syndrome, look for right ventricle strain).
- Identify haemodynamic instability and high-risk PE.
- Perform bedside echocardiography.
- Initiate anticoagulation therapy (heparin 80 IU/kg IV) during diagnostic process, unless signs of bleeding or absolute contraindications.
- Confirm diagnosis with computed tomographic pulmonary angiography (CTPA).
- Set-up a multidisciplinary team for making decisions on management of high-risk PE (depending on local resources).
- Give rescue thrombolytic therapy in rapidly deteriorating patients.
- Consider surgical embolectomy or catheter-directed treatment as alternative to rescue thrombolytic therapy in rapidly deteriorating patients.

Exposure

- Request information about past medical history, predisposing factors, and medication that may support diagnosis of pulmonary embolism:
  - Previous pulmonary embolism or deep venous thrombosis (DVT).
  - Surgery or immobilisation within the past four weeks.
  - Active cancer.
  - Clinical signs of DVT.
  - Oral contraceptive use or hormone replacement therapy.
  - Long-distance flights.

Cardiac arrest management

- Cardiac arrest commonly presents as PEA.
- Low $ETCO_2$ readings (below 1.7 kPa/13 mmHg) while performing high-quality chest compressions may support a diagnosis of pulmonary embolism, although it is a non-specific sign.
- Consider emergency echocardiography performed by a qualified sonographer as an additional diagnostic tool.
- Administer thrombolytic drugs for cardiac arrest when PE is the suspected cause of cardiac arrest.
- When thrombolytic drugs have been administered, consider continuing CPR attempts for at least 60−90 min before termination of resuscitation attempts.
- Use thrombolytic drugs or surgical embolectomy or percutaneous mechanical thrombectomy for cardiac arrest when PE is the known cause of cardiac arrest.
- Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it can be implemented.

Coronary thrombosis

Prevent and be prepared:

- Encourage cardiovascular prevention to reduce the risk of acute events.
- Endorse health education to reduce delay to first medical contact.
- Promote layperson basic life support to increase the chances of bystander CPR.
- Ensure adequate resources for better management.
- Improve quality management systems and indicators for better quality monitoring.

Detect parameters suggesting coronary thrombosis and activate the ST-elevation myocardial infarction (STEMI) network:

- Chest pain prior to arrest.
- Known coronary artery disease.
- Initial rhythm: VF, pulseless ventricular tachycardia (pVT).
- Post-resuscitation 12-lead ECG showing ST-elevation.

Resuscitate and treat possible causes (establish reperfusion strategy):

- Patients with sustained ROSC
  - STEMI patients:
    - ➢ Primary percutaneous coronary intervention (PCI) strategy ≤120 min from diagnosis: activate catheterisation laboratory and transfer patient for immediate PCI.
    - ➢ Primary PCI not possible in ≤120 min: perform pre-hospital thrombolysis and transfer patient to PCI centre.
  - Non STEMI patients: individualise decisions considering patient characteristics, OHCA setting and ECG findings.
    - ➢ Consider quick diagnostic work-up (discard non-coronary causes and check patient condition).
    - ➢ Perform urgent coronary angiography (≤120 min) if ongoing myocardial ischaemia is suspected or the patient is hemodynamically/electrically instable.

    - ➢ Consider delayed coronary angiography if there is no suspected ongoing ischaemia and the patient is stable.
- Patients with no sustained ROSC: Assess setting and patient conditions and available resources
    - Futile: Stop CPR.
    - Not-futile: Consider patient transfer to a percutaneous coronary intervention (PCI) centre with on-going CPR.
        - ➢ Consider mechanical compression and ECPR.
        - ➢ Consider coronary angiography.

Cardiac tamponade

- Decompress the pericardium immediately.
- Point of care echocardiography supports the diagnosis.
- Perform resuscitative thoracotomy or ultrasound guided pericardiocentesis.

Tension pneumothorax

- Diagnosis of tension pneumothorax in a patient with cardiac arrest or haemodynamic instability must be based on clinical examination or point of care ultrasound (POCUS).
- Decompress chest immediately by open thoracostomy when a tension pneumothorax is suspected in the presence of cardiac arrest or severe hypotension.
- Needle chest decompression serves as rapid treatment, it should be carried out with specific needles (longer, non-kinking).
- Any attempt at needle decompression under CPR should be followed by an open thoracostomy or a chest tube if the expertise is available.
- Chest decompression effectively treats tension pneumothorax and takes priority over other measures.

Toxic agents

Prevention

- Poisoning rarely causes cardiac arrest.
- Manage hypertensive emergencies with benzodiazepines, vasodilators and pure alpha-antagonists.
- Drug induced hypotension usually responds to IV fluids.
- Use specific treatments where available in addition to the ALS management of arrhythmias.
- Provide early advanced airway management.
- Administer antidotes, where available, as soon as possible.

Cardiac arrest treatment

- Have a low threshold to ensure your personal safety.
- Consider using specific treatment measures as antidotes, decontamination and enhanced elimination.
- Do not use mouth-to-mouth ventilation in the presence of chemicals such as cyanide, hydrogen sulphide, corrosives and organophosphates.
- Exclude all reversible causes of cardiac arrest, including electrolyte abnormalities which can be indirectly caused by a toxic agent.
- Measure the patient's temperature because hypo- or hyperthermia may occur during drug overdose.
- Be prepared to continue resuscitation for a prolonged time. The toxin concentration may fall as it is metabolised or excreted during extended resuscitation measures.
- Consult regional or national poison centres for information on treatment of the poisoned patient.
- Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it can be implemented.

Special settings

Healthcare facilities

Cardiac arrest in the operating room (OR)

- Recognise cardiac arrest by continuous monitoring.
- Inform the surgeon and the theatre team. Call for help and the defibrillator.
- Initiate high-quality chest compressions and effective ventilation.
- Follow the ALS algorithm with a strong focus on reversible causes, especially hypovolaemia (anaphylaxis, bleeding), hypoxia, tension-pneumothorax, thrombosis (pulmonary embolism).
- Use ultrasound to guide resuscitation
- Adjust the height of the OR table to enable high-quality CPR.
- Check the airway and review the $EtCO_2$ tracing.
- Administer oxygen with a FiO_2 1.0.
- Open cardiac compression should be considered as an effective alternative to closed chest compression.
- Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing.

Cardiac surgery

Prevent and be prepared

- Ensure adequate training of the staff in resuscitation technical skills and ALS.
- Ensure equipment for emergency re-sternotomy is available in the ICU.
- Use safety checklists.

Detect cardiac arrest and activate cardiac arrest protocol:

- Identify and manage deterioration in the postoperative cardiac patient.
- Consider echocardiography.
- Confirm cardiac arrest by clinical signs and pulseless pressure waveforms.
- Shout for help and activate cardiac arrest protocol.

Resuscitate and treat possible causes

- Resuscitate according to ALS MODIFIED algorithm:
    - VF/pVT → Defibrillate: apply up to 3 consecutive shocks (< 1 min).
    - Asystole/extreme bradycardia → Apply early pacing (< 1 min).
    - PEA → Correct potentially reversible causes. If paced rhythm, turn off pacing to exclude VF.

→ No ROSC:

- Initiate chest compression and ventilation.
- Perform early resternotomy (<5 min).
- Consider circulatory support devices and ECPR (Figure CS1).

Catheterisation laboratory

Prevent and be prepared

- Ensure adequate training of the staff in resuscitation technical skills and ALS.
- Use safety checklists.

Detect cardiac arrest and activate cardiac arrest protocol

- Check patient's status and monitored vital signs periodically.
- Consider cardiac echocardiography in case of haemodynamic instability or suspected complication.
- Shout for help and activate cardiac arrest protocol.

Resuscitate and treat possible causes

- Resuscitate according to the MODIFIED ALS algorithm:
  - VF/pVT cardiac arrest → Defibrillate (apply up to 3 consecutive shocks) → no ROSC → resuscitate according to ALS algorithm.
  - Asystole/PEA → resuscitate according to ALS algorithm.
- Check and correct potentially reversible causes, including the use of echocardiography and angiography.
- Consider mechanical chest compression and circulatory support devices (including ECPR).

Dialysis unit

- Follow the universal ALS algorithm.
- Assign a trained dialysis nurse to operate the haemodialysis (HD) machine.
- Stop dialysis and return the patient's blood volume with a fluid bolus.
- Disconnect from the dialysis machine (unless defibrillation-proof) in accordance with the International Electrotechnical Committee (IEC) standards.
- Leave dialysis access open to use for drug administration.
- Dialysis may be required in the early post resuscitation period.
- Provide prompt management of hyperkalaemia.
- Avoid excessive potassium and volume shifts during dialysis.

Dentistry

- Causes of cardiac arrest usually relate to pre-existing comorbidities, complications of the procedure or allergic reactions.
- All dental care professionals should undergo annual practical training in the recognition and management of medical emergencies, including the delivery of CPR, incl. basic airway management and the use of an AED.
- Check patient's mouth and remove all solid materials from the oral cavity (e.g. retractor, suction tube, tampons). Prevention of foreign body airway obstruction should precede positioning.
- Recline the dental chair into a fully horizontal position. If reduced venous return or vasodilation has caused loss of consciousness (e.g. vasovagal syncope, orthostatic hypotension), cardiac output can be restored.
- Place a stool under the backrest for stabilisation.
- Start chest compressions immediately while patient lying flat on the chair.
- Consider the over-the-head technique of CPR if access to either side of chest is limited.
- Basic equipment for a standard CPR including a bag-valve-mask device should be available immediately.

Transportation

Inflight cardiac arrest

- Medical professional help should be sought (in-flight announcement).
- The rescuer should kneel in the leg-space in front of the aisle seats to perform chest compressions if the patient cannot be transferred within a few seconds to an area with adequate floor space (galley).
- Overhead-CPR is a possible option in limited space environments.
- Airway management should be based on the equipment available and the expertise of the rescuer.
- If the flight plan is over open water with high possibility of ROSC during an ongoing resuscitation consider an early diversion.
- Consider risks of diversion if ROSC is unlikely and give appropriate recommendations to the flight crew.
- If CPR is terminated (no ROSC) a flight diversion should not usually be performed.

Helicopter emergency medical services (HEMS) and air ambulances

- Proper pre-flight-evaluation of the patient, early recognition and communication within the team, early defibrillation, high-quality CPR with minimal interruption of chest compressions, and treatment of reversible causes before flight are the most important interventions for the prevention of CPR during HEMS missions.
- Check the patient status properly before flight. Sometimes ground-based transport might be a suitable alternative, especially for patients with high-risk of cardiac arrest.
- Check security of the airway and ventilator connections prior to flight. For a cardiac arrest in an unventilated patient during flight consider an SGA for initial airway management.
- Pulse oximetry (SpO_2) monitoring and oxygen supplementation should be available immediately if not already attached.
- CPR should be performed as soon as possible, over-the-head-CPR (OTH-CPR) might be possible depending on the type of helicopter.
- If cabin size does not allow high-quality CPR, consider immediate landing.
- Always consider attaching a mechanical CPR device before flight.
- Consider three stacked shocks in case of shockable rhythm during flight.
- Defibrillation during flight is safe.

Cruise ship

- Use all medical resources immediately (personal, equipment).
- Activate HEMS if close to the coastline.
- Consider early telemedicine support.
- Have all equipment needed for ALS available on board.
- In case of insufficient number of health care professionals to treat CA, call for further medical staff via an on-board announcement.

Cardiac arrest in sport

Planning

- All sports and exercise facilities should undertake a medical risk assessment of the risk of sudden cardiac arrest.
- Where there is a raised risk, mitigation must include resuscitation planning to include:
  - Staff and members training in the recognition and management of cardiac arrest.
  - Direct provision of an AED or clear directions to the nearest public access AED.

Implementation

- Recognise collapse.
- Gain immediate and safe access to the Field of Play.
- Call for help and activate EMS.

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- Assess for signs of life.
- If no signs of life:
  - commence CPR.
  - access an AED and defibrillate if indicated.
- If ROSC occurs, carefully observe and monitor the casualty until advanced medical care arrives.
- If there is no ROSC:
  - Continue cardio-pulmonary resuscitation and defibrillation until advanced medical care arrives.
  - In a sport arena, consider moving patient to a less exposed position and continue resuscitation. This should be accomplished with minimal interruption to chest compressions.

Prevention

- Do not undertake exercise, especially extreme exercise or competitive sport, if feeling unwell.
- Follow medical advice in relation to the levels of exercise or sport competition.
- Consider cardiac screening for young athletes undertaking high level competitive sport.

Drowning

Initial rescue

- Undertake a dynamic risk assessment considering feasibility, chances of survival and risks to the rescuer:
  - Submersion duration is the strongest predictor of outcome.
  - Salinity has an inconsistent effect on outcome.
- Assess consciousness and breathing:
  - If conscious and/or breathing normally, aim to prevent cardiac arrest.
  - If unconscious and not breathing normally, start resuscitation.

Cardiac arrest prevention

Airway

- Ensure a patent airway.
- Treat life threatening hypoxia with 100% inspired oxygen until the arterial oxygen saturation or the partial pressure of arterial oxygen can be measured reliably.
- Once SpO_2 can be measured reliably or arterial blood gas values are obtained, titrate the inspired oxygen to achieve an arterial oxygen saturation of 94–98% or arterial partial pressure of oxygen (PaO_2) of 10–13 kPa (75–100 mmHg).

Breathing

- Assess respiratory rate, accessory muscle use, ability to speak in full sentences, pulse oximetry, percussion and breath sounds; request chest X-ray.
- Consider non-invasive ventilation if respiratory distress and safe to do so.
- Consider invasive mechanical ventilation if respiratory distress and unsafe or unable to initiate non-invasive ventilation.
- Consider extracorporeal membrane oxygenation if poor response to invasive ventilation.

Circulation

- Assess heart rate and blood pressure, attach ECG.
- Obtain IV access.
- Consider IV fluids and/or vasoactive drugs to support the circulation.

Disability

- Assess using AVPU or GCS.

Exposure

- Measure core temperature.
- Initiate hypothermia algorithm if core temperature $<35\,^{\circ}C$.

Cardiac arrest

- Start resuscitation as soon as safe and practical to do so. If trained and able this might include initiating ventilations whilst still in the water or providing ventilations and chest compressions on a boat.
- Start resuscitation by giving 5 rescue breaths/ventilations using 100% inspired oxygen if available.
- If the person remains unconscious, without normal breathing, start chest compressions.
- Alternate 30 chest compressions to 2 ventilations.
- Apply an AED if available and follow instructions.
- Intubate the trachea if able to do so safely.
- Consider ECPR in accordance with local protocols if initial resuscitation efforts are unsuccessful.

Mass casualty incidents

- Identify hazards and immediately request assistance if necessary.
- Use adequate personal protection equipment (PPE) (e.g. bulletproof vest, respirator, long-sleeved gown, eye and face protection) depending on specific risks on scene.
- Reduce secondary risks to other patients and providers.
- Use a locally established triage system to prioritise treatment.
- Perform life-saving interventions in patients triaged as “immediate” (highest priority) to prevent cardiac arrest.
- Consider assigning a higher triage risk level to elderly and to survivors of high-energy trauma in order to reduce preventable deaths.
- Healthcare professionals must be regularly trained to use the triage protocols during simulations and live exercises.

Special patients

Asthma and COPD

Cardiac arrest prevention

Airway

- Ensure a patent airway.
- Treat life threatening hypoxia with high flow oxygen.
- Titrate subsequent oxygen therapy with pulse oximetry (SpO_2 94–98% for asthma; 88–92% for chronic obstructive pulmonary disease (COPD)).

Breathing

- Assess respiratory rate, accessory muscle use, ability to speak in full sentences, pulse oximetry, percussion and breath sounds; request chest X-ray.
- Look for evidence of pneumothorax/tension pneumothorax.
- Provide nebulised bronchodilators (oxygen driven for asthma, consider air driven for COPD).

- Administer steroids (Prednisolone 40–50 mg or hydrocortisone 100 mg).
- Consider IV magnesium sulphate for asthma.
- Seek senior advice before giving IV aminophylline or salbutamol.

Circulation

- Assess heart rate and blood pressure, attach ECG.
- Obtain vascular access.
- Consider IV fluids.

Cardiac arrest treatment

- Administer high concentration oxygen.
- Ventilate with respiratory rate (8–10 min^{-1}) and sufficient tidal volume to cause the chest to rise.
- Intubate the trachea if able to do so safely.
- Check for signs of tension pneumothorax and treat accordingly.
- Disconnect from positive pressure ventilation if relevant and apply pressure to manually reduce hyper-inflation.
- Consider IV fluids.
- Consider E-CPR in accordance with local protocols if initial resuscitation efforts are unsuccessful.

Neurological disease

- There are no modifications required in the BLS and ALS management of cardiac arrest from a primary neurological cause.
- Following ROSC, consider clinical features such as young age, female sex, non-shockable rhythm and neurological antecedents such as headache, seizures, and focal neurological deficit when suspecting a neurological cause of cardiac arrest.
- Early identification of a neurological cause can be achieved by performing a brain CT-scan at hospital admission, before or after coronary angiography.
- In the absence of signs or symptoms suggesting a neurological cause (e.g. headache, seizures or neurological deficits) or if there is clinical or ECG evidence of myocardial ischaemia, coronary angiography is undertaken first, followed by CT scan in the absence of causative lesions.

Obesity

- Delivery of effective CPR in obese patients may be challenging due to a number of factors:
  - patient access and transportation
  - vascular access
  - airway management
  - quality of chest compressions
  - efficacy of vasoactive drugs
  - efficacy of defibrillation

- Provide chest compressions up to a maximum of 6 cm.
- Obese patients lying in a bed do not necessarily need to be moved down onto the floor.
- Change the rescuers performing chest compression more frequently.
- Consider escalating defibrillation energy to maximum for repeated shocks.
- Manual ventilation with a bag-mask should be minimised and be performed by experienced staff using a two-person technique.
- An experienced provider should intubate the trachea early so that the period of bag-mask ventilation is minimised.

Pregnancy

Prevention of cardiac arrest in the deteriorating pregnant patient

- Use a validated obstetric early warning scoring system when caring for the ill-pregnant patient.
- Use a systematic ABCDE approach to assess and treat the pregnant patient.
- Place the patient in the left lateral position or manually and gently displace the uterus to the left to relieve aortocaval compression.
- Give oxygen guided by pulse oximetry to correct hypoxaemia.
- Give a fluid bolus if there is hypotension or evidence of hypovolaemia.
- Immediately re-evaluate the need for any drugs being given.
- Seek expert help early – obstetric, anaesthetic, critical care and neonatal specialists should be involved early in the resuscitation.
- Identify and treat the underlying cause of cardiac arrest, e.g. control of bleeding, sepsis.
- Give intravenous tranexamic acid 1 g IV for postpartum haemorrhage.

Modification for advanced Life support in the pregnant patient

- Call for expert help early (including an obstetrician and neonatologist).
- Start basic life support according to standard guidelines.
- Use the standard hand position for chest compressions on the lower half of the sternum if feasible.
- If over 20 weeks pregnant or the uterus is palpable above the level of the umbilicus:
  - Manually displace the uterus to the left to remove aortocaval compression.
  - If feasible, add left lateral tilt – the chest should remain on supported on a firm surface (e.g. in the operating room). The optimal angle of tilt is unknown. Aim for a tilt between 15 and 30 degrees. Even a small amount of tilt may be better than no tilt. The angle of tilt used needs to enable high-quality chest compressions and if needed allow caesarean delivery of the foetus.
- Prepare early for emergency hysterostomy early – the foetus will need to be delivered if immediate (within 4 min) resuscitation efforts fail.
- If over 20 weeks pregnant or the uterus is palpable above the level of the umbilicus and immediate (within 4 min) resuscitation is unsuccessful, deliver the foetus by emergency caesarean section aiming for delivery within 5 min of collapse.
- Place defibrillator pads in the standard position as far as possible and use standard shock energies.
- Consider early tracheal intubation by a skilled operator.
- Identify and treat reversible causes (e.g. haemorrhage). Focused ultrasound by a skilled operator may help identify and treat reversible causes of cardiac arrest.
- Consider extracorporeal CPR (ECPR) as a rescue therapy if ALS measures are failing.

Preparation for cardiac arrest in pregnancy

- Healthcare settings dealing with cardiac arrest in pregnancy should:
  - have plans and equipment in place for resuscitation of both the pregnant woman and the newborn.

- ensure early involvement of obstetric, anaesthetic, critical care and neonatal teams.
- ensure regular training in obstetric emergencies.

Post resuscitation care

The European Resuscitation Council (ERC) and the European Society of Intensive Care

Medicine (ESICM) have collaborated to produce these post-resuscitation care guidelines for adults, which are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. The topics covered include the post-cardiac arrest syndrome, control of oxygenation and ventilation, haemodynamic targets, coronary reperfusion, targeted temperature management, control of seizures, prognostication, rehabilitation, and long-term outcome.

These guidelines introduce relatively few major changes from the 2015 ERC-ESICM Guidelines on Post-Resuscitation Care. Key changes comprise guidance on general intensive care management such as use of neuromuscular blocking drugs, stress ulcer prophylaxis and nutrition, greater detail on the treatment of seizures, modifications to prognostication algorithm, greater emphasis on functional assessments of physical and non-physical impairments before discharge and long-term follow up and rehabilitation. Recognition of the importance of survivorship after cardiac arrest.

Key messages from this section are presented in Fig. 10. The post resuscitation care algorithm is presented in Fig. 11.

Immediate post-resuscitation care

- Post-resuscitation care is started immediately after sustained ROSC, regardless of location.
- For out-of-hospital cardiac arrest consider transport to a cardiac arrest centre.

Diagnosis of cause of cardiac arrest

- Early identification of a respiratory or neurological cause can be achieved by performing a brain and chest CT-scan at hospital admission, before or after coronary angiography (see coronary reperfusion).
- In the absence of signs or symptoms suggesting a neurological or respiratory cause (e.g. headache, seizures or neurological deficits, shortness of breath or documented hypoxaemia in patients with known respiratory disease) or if there is clinical or ECG evidence of myocardial ischaemia, undertake coronary angiography first. This is followed by CT scan if coronary angiography fails to identify causative lesions.

Airway and breathing

Airway management after return of spontaneous circulation

- Airway and ventilation support should continue after return of spontaneous circulation (ROSC) is achieved.
- Patients who have had a brief period of cardiac arrest and an immediate return of normal cerebral function and are breathing normally may not require tracheal intubation but should be given oxygen via a facemask if their arterial blood oxygen saturation is less than 94%.
- Patients who remain comatose following ROSC, or who have another clinical indication for sedation and mechanical ventilation, should have their trachea intubated if this has not been done already during CPR.
- Tracheal intubation should be performed only by experienced operators who have a high success rate.
- Placement of the tracheal tube must be confirmed with waveform capnography.

Control of oxygenation

- After ROSC, use 100% (or maximum available) inspired oxygen until the arterial oxygen saturation or the partial pressure of arterial oxygen can be measured reliably.
- After ROSC, once SpO_2 can be measured reliably or arterial blood gas values are obtained, titrate the inspired oxygen to achieve an arterial oxygen saturation of 94–98% or arterial partial pressure of oxygen (PaO_2) of 10–13 kPa or 75–100 mmHg.
- Avoid hypoxaemia ($PaO_2 < 8$ kPa or 60 mmHg) following ROSC.
- Avoid hyperoxaemia following ROSC.

Control of ventilation

- Obtain an arterial blood gas and use end tidal CO_2 in mechanically ventilated patients.
- In patients requiring mechanical ventilation after ROSC, adjust ventilation to target a normal arterial partial pressure of carbon dioxide ($PaCO_2$) i.e. 4.5–6.0 kPa or 35–45 mmHg.
- In patients treated with targeted temperature management (TTM) monitor $PaCO_2$ frequently as hypocapnia may occur.
- During TTM and lower temperatures use consistently either a temperature or non-temperature corrected approach for measuring blood gas values.
- Use a lung protective ventilation strategy aiming for a tidal volume of 6–8 mL kg^{-1} ideal body weight.

Circulation

Coronary reperfusion

- Emergent cardiac catheterisation laboratory evaluation (and immediate PCI if required) should be performed in adult patients with ROSC after cardiac arrest of suspected cardiac origin with ST-elevation on the ECG.
- In patients with ROSC after out-of-hospital cardiac arrest (OHCA) without ST-elevation on the ECG, emergent 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).

Haemodynamic monitoring and management

- All patients should be monitored with an arterial line for continuous blood pressure measurements, and it is reasonable to monitor cardiac output in haemodynamically unstable patients.
- Perform early echocardiography in all patients to detect any underlying pathology and quantify the degree of myocardial dysfunction.
- Avoid hypotension (<65 mmHg). Target mean arterial pressure (MAP) to achieve adequate urine output (>0.5 mL $kg^{-1}h^{-1}$) and normal or decreasing lactate.
- During TTM at 33 °C, bradycardia may be left untreated if blood pressure, lactate, $ScvO_2$ or SvO_2 is adequate. If not, consider increasing the target temperature.

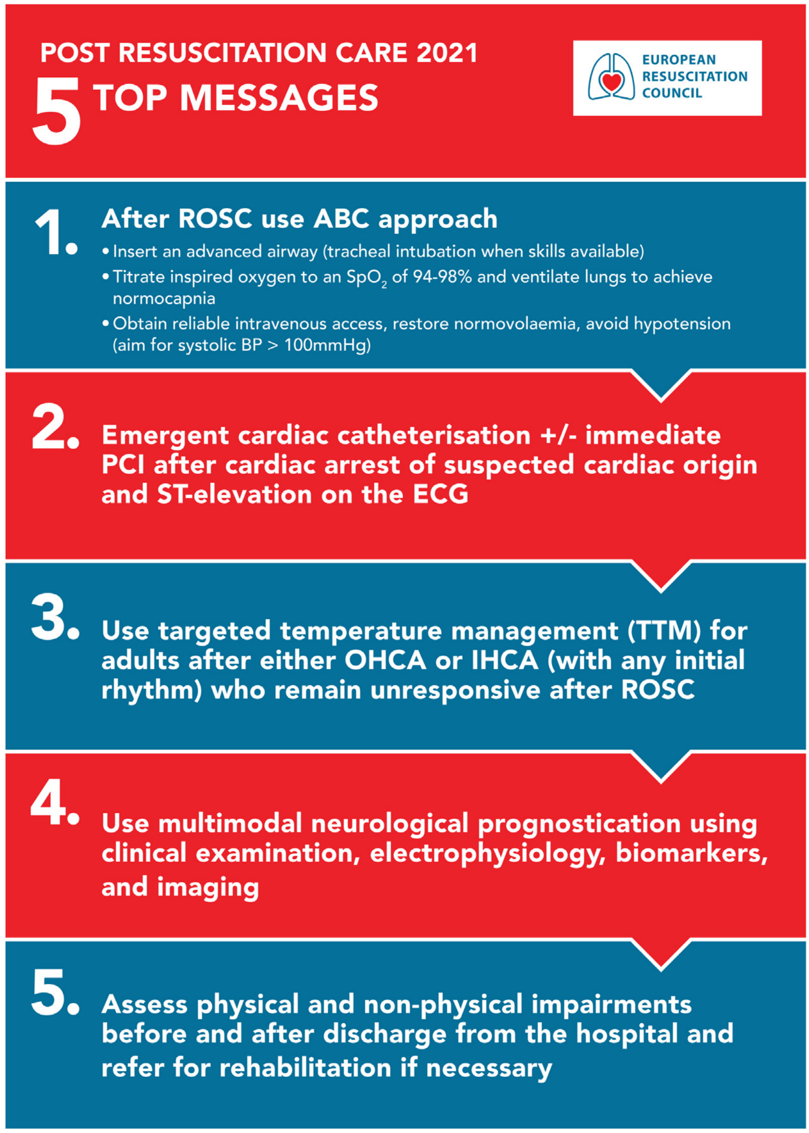

Fig. 10 – Post resuscitation care infographic summary.

- Maintain perfusion with fluids, noradrenaline and/or dobutamine, depending on individual patient need for intravascular volume, vasoconstriction or inotropy.
- Do not give steroids routinely after cardiac arrest.
- Avoid hypokalaemia, which is associated with ventricular arrhythmias.
- Consider mechanical circulatory support (such as intra-aortic balloon pump, left-ventricular assist device or arterio-venous extra corporal membrane oxygenation) for persisting cardiogenic shock if treatment with fluid resuscitation, inotropes, and vasoactive drugs is insufficient.

Disability (optimising neurological recovery)

Control of seizures

- To treat seizures after cardiac arrest, we suggest levetiracetam or sodium valproate as first-line antiepileptic drugs in addition to sedative drugs.
- We recommend using electroencephalography (EEG) to diagnose electrographic seizures in patients with clinical convulsions and to monitor treatment effects.
- We suggest that routine seizure prophylaxis is not used in post-cardiac arrest patients.

Temperature control

- We recommend targeted temperature management (TTM) for adults after either OHCA or in-hospital cardiac arrest (IHCA) (with any initial rhythm) who remain unresponsive after ROSC.
- Maintain a constant target temperature between 32 °C and 36 °C for at least 24 h.
- Avoid fever for at least 72 h after ROSC in patients who remain in coma.
- Do not use pre-hospital intravenous cold fluids to initiate hypothermia.

General intensive care management

- Use short acting sedatives and opioids.

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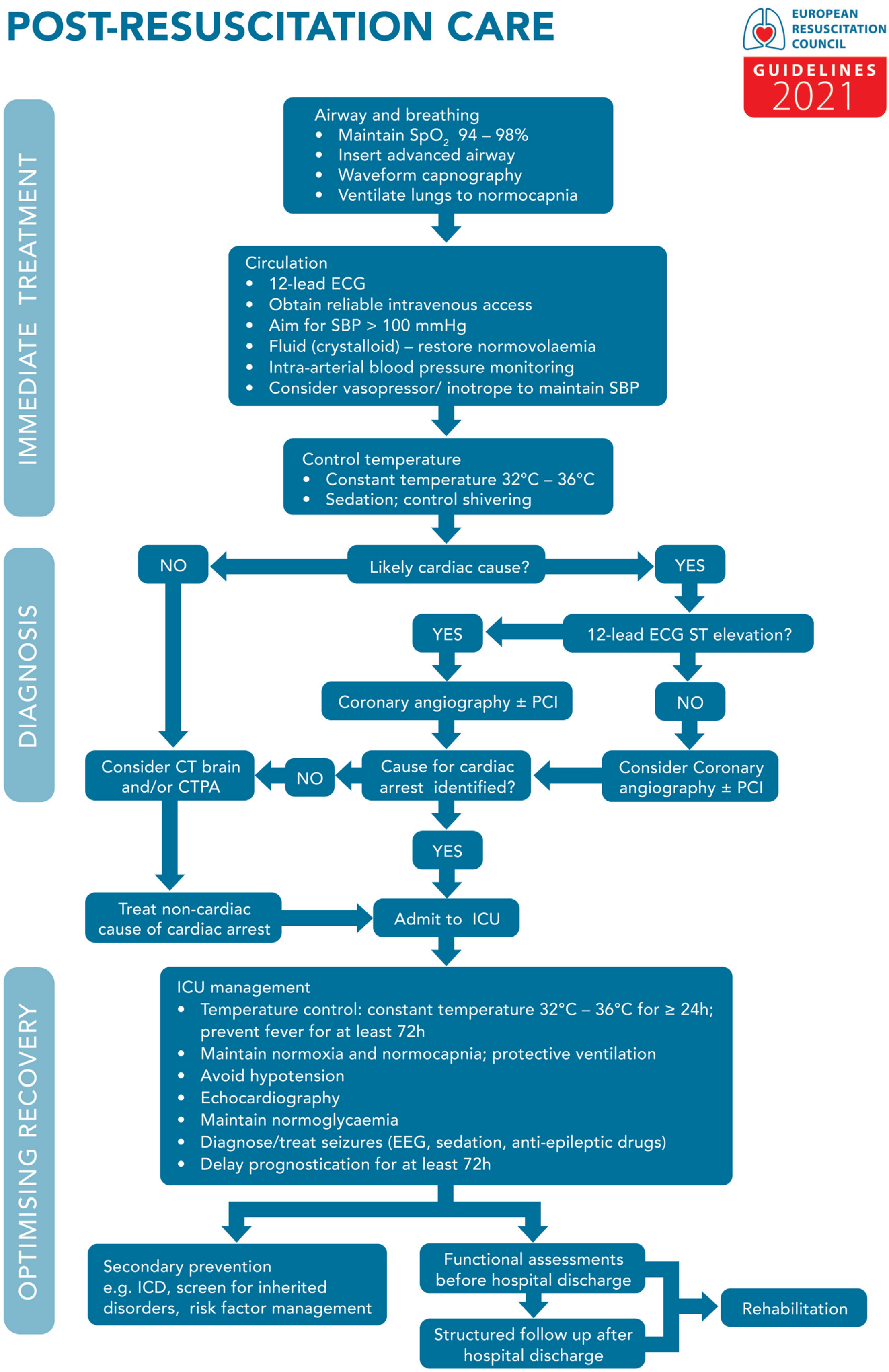

Fig. 11 – Post resuscitation care algorithm.

- Avoid using a neuromuscular blocking drug routinely in patients undergoing TTM, but it may be considered in case of severe shivering during TTM.
- Provide stress ulcer prophylaxis routinely in cardiac arrest patients.
- Provide deep venous thrombosis prophylaxis.
- Target a blood glucose of 5−10 mmol L^{-1} (90−180 mg dL^{-1}) using an infusion of insulin if required.
- Start enteral feeding at low rates (trophic feeding) during TTM and increase after rewarming if indicated. If TTM of 36 °C is used as the target temperature, trophic gastric feeding may be started even earlier.
- We do not recommend using prophylactic antibiotics routinely.

Prognostication

General guidelines

- In patients who are comatose after resuscitation from cardiac arrest, neurological prognostication should be performed using clinical examination, electrophysiology, biomarkers, and imaging, to both inform patient's relatives and to help clinicians to target treatments based on the patient's chances of achieving a neurologically meaningful recovery.
- No single predictor is 100% accurate. Therefore, a multimodal neuroprognostication strategy is recommended.
- When predicting poor neurological outcome, a high specificity and precision are desirable, to avoid falsely pessimistic predictions.
- The clinical neurological examination is central to prognostication. To avoid falsely pessimistic predictions, clinicians should avoid potential confounding from sedatives and other drugs that may confound the results of the tests.
- Clinicians must be aware of the risk of a self-fulfilling prophecy bias, occurring when the results of an index test predicting poor outcome is used for treatment decisions, especially regarding life-sustaining therapies.
- Index tests for neurological prognostication are aimed at assessing the severity of hypoxic-ischaemic brain injury (hypoxic-ischaemic brain injury). The neurological prognosis is one of several aspects to consider in discussions around an individual's potential for recovery.

Clinical examination

- Clinical examination is prone to interference from sedatives, opioids or muscle relaxants. A potential confounding from residual sedation should always be considered and excluded.
- A Glasgow Motor Score of ≤3 (abnormal flexion or worse in response to pain) at 72 h or later after ROSC may identify patients in whom neurological prognostication may be needed.
- In patients who remain comatose at 72 h or later after ROSC the following tests may predict a poor neurological outcome:
  - The bilateral absence of the standard pupillary light reflex.
  - Quantitative pupillometry
  - The bilateral absence of corneal reflex
  - The presence of myoclonus or status myoclonus within 96 h
- We also suggest recording the EEG in the presence of myoclonic jerks in order to detect any associated epileptiform activity or to identify EEG signs, such as background reactivity or continuity, suggesting a potential for neurological recovery.

Neurophysiology

- Perform an EEG in patients who are unconscious after the arrest.
- Highly malignant EEG-patterns include suppressed background with or without periodic discharges and burst-suppression. We suggest using these EEG-patterns after the end of TTM and after sedation has been cleared as indicators of a poor prognosis.
- The presence of unequivocal seizures on EEG during the first 72 h after ROSC is an indicator of a poor prognosis.
- Absence of background reactivity on EEG is an indicator of poor prognosis after cardiac arrest.
- Bilateral absence of somatosensory evoked cortical N20-potentials is an indicator of poor prognosis after cardiac arrest.
- Always consider the results of EEG and somatosensory evoked potentials (SSEP) in the context of clinical examination findings and other tests. Always consider using a neuromuscular blocking drug when performing SSEP.

Biomarkers

- Use serial measurements of neuron-specific enolase (NSE) in combination with other methods to predict outcome after cardiac arrest. Increasing values between 24 and 48 h or 72 h in combination with high values at 48 and 72 h indicates a poor prognosis.

Imaging

- Use brain imaging studies for predicting poor neurological outcome after cardiac arrest in combination with other predictors, in centres where specific experience in these studies is available.
- Use presence of generalised brain oedema, manifested by a marked reduction of the grey matter/white matter ratio on brain CT, or extensive diffusion restriction on brain MRI to predict poor neurological outcome after cardiac arrest.
- Always consider findings from imaging in combination with other methods for neurological prognostication.

Multimodal prognostication

- Start the prognostication assessment with an accurate clinical examination, to be performed only after major confounders – especially residual sedation – have been excluded.
- In a comatose patient with M ≤ 3 at ≥72 h from ROSC, in the absence of confounders, poor outcome is likely when two or more of the following predictors are present: no pupillary and corneal reflexes at ≥72 h, bilaterally absent N20 SSEP wave at ≥24 h, highly malignant EEG at >24 h, NSE >60 μg L^{-1} at 48 h and/or 72 h, status myoclonus ≤72 h, or a diffuse and extensive anoxic injury on brain CT/MRI. Most of these signs can be recorded before 72 h from ROSC, however their results will be evaluated only at the time of clinical prognostic assessment.

Withdrawal of life-sustaining therapy

- Separate discussions around withdrawal of life-sustaining therapy (WLST) and the assessment of prognosis for neurological recovery; WLST decisions should consider aspects other than brain injury such as age, co-morbidity, general organ function and the patients' preferences.

- Allocate sufficient time for communication around the level-of-treatment decision within the team and with the relatives.

Long-term outcome after cardiac arrest

- Perform functional assessments of physical and non-physical impairments before discharge from the hospital to identify early rehabilitation needs and refer to rehabilitation if necessary.
- Organise follow-up for all cardiac arrest survivors within 3 months after hospital discharge, including:

1. Screening for cognitive problems.
2. Screening for emotional problems and fatigue.
3. Providing information and support for survivors and family members.

Organ donation

- All decisions concerning organ donation must follow local legal and ethical requirements.
- Organ donation should be considered in those who have achieved ROSC and who fulfil neurological criteria for death.
- In comatose ventilated patients, when a decision to start end-of-life care and withdrawal of life support is made, organ donation should be considered after circulatory arrest occurs.

Cardiac arrest centres

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocol.

First aid

The European Resuscitation Council has produced these first aid guidelines, which are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. The topics include the first aid management of emergency medicine and trauma. For medical emergencies the following content is covered: recovery position, optimal positioning for shock, bronchodilator administration for asthma, recognition of stroke, early aspirin for chest pain, second dose of adrenaline for anaphylaxis, management of hypoglycaemia, oral rehydration solutions for treating exertion-related dehydration, management of heat stroke by cooling, supplemental oxygen in acute stroke, and presyncope. For trauma related emergencies the following topics are covered: control of life-threatening bleeding, management of open chest wounds, cervical spine motion restriction and stabilisation, recognition of concussion, cooling of thermal burns, dental avulsion, compression wrap for closed extremity joint injuries, straightening an angulated fracture, and eye injury from chemical exposure.

Key messages from this section are presented in Fig. 12.

Recovery position

For adults and children with a decreased level of responsiveness due to medical illness or non-physical trauma, who do NOT meet the criteria for the initiation of rescue breathing or chest compressions (CPR), the ERC recommends they be placed into a lateral, side-lying, recovery position. Overall, there is little evidence to suggest an optimal recovery position, but the ERC recommends the following sequence of actions:

- Kneel beside the victim and make sure that both legs are straight
- Place the arm nearest to you out at right angles to the body with the hand palm uppermost
- Bring the far arm across the chest, and hold the back of the hand against the victim's cheek nearest to you
- With your other hand, grasp the far leg just above the knee and pull it up, keeping the foot on the ground
- Keeping the hand pressed against the cheek, pull on the far leg to roll the victim towards you onto their side
- Adjust the upper leg so that both hip and knee are bent at right angles
- Tilt the head back to make sure the airway remains open
- Adjust the hand under the cheek if necessary, to keep the head tilted and facing downwards to allow liquid material to drain from the mouth
- Check regularly for normal breathing
- Only leave the victim unattended if absolutely necessary, for example to attend to other victims.

It is important to stress the importance of maintaining a close check on all unresponsive individuals until the EMS arrives to ensure that their breathing remains normal. In certain situations, such as resuscitation-related agonal respirations or trauma, it may not be appropriate to move the individual into a recovery position.

Optimal position for shock victim

- Place individuals with shock into the supine (lying-on-back) position.
- Where there is no evidence of trauma first aid, providers might consider the use of passive leg raising as a temporising measure while awaiting more advanced emergency medical care.

Bronchodilator administration for asthma

- Assist individuals with asthma who are experiencing difficulty in breathing with their bronchodilator administration.
- First aid providers must be trained in the various methods of administering a bronchodilator.

Recognition of stroke

- Use a stroke assessment scale to decrease the time to recognition and definitive treatment for individual suspected of acute stroke.
- The following stroke assessment scales are available:
  - Face Arm Speech Time to call (FAST)
  - Melbourne Ambulance Stroke Scale (MASS)
  - Cincinnati Prehospital Stroke Scale (CPSS)
  - Los Angeles Prehospital Stroke Scale (LAPSS) are the most common.
- The MASS and LAPSS scales can be augmented by blood glucose measurement.

Early aspirin for chest pain

- For conscious adults with non-traumatic chest pain due to suspected myocardial infarction:
- Reassure the casualty
- Sit or lie the casualty in a comfortable position
- Call for help
- First aid providers should encourage and assist the casualty in the self-administration of 150–300 mg chewable aspirin as soon as possible after the onset of chest pain
- Do not administer aspirin to adults with chest pain of unclear or traumatic aetiology

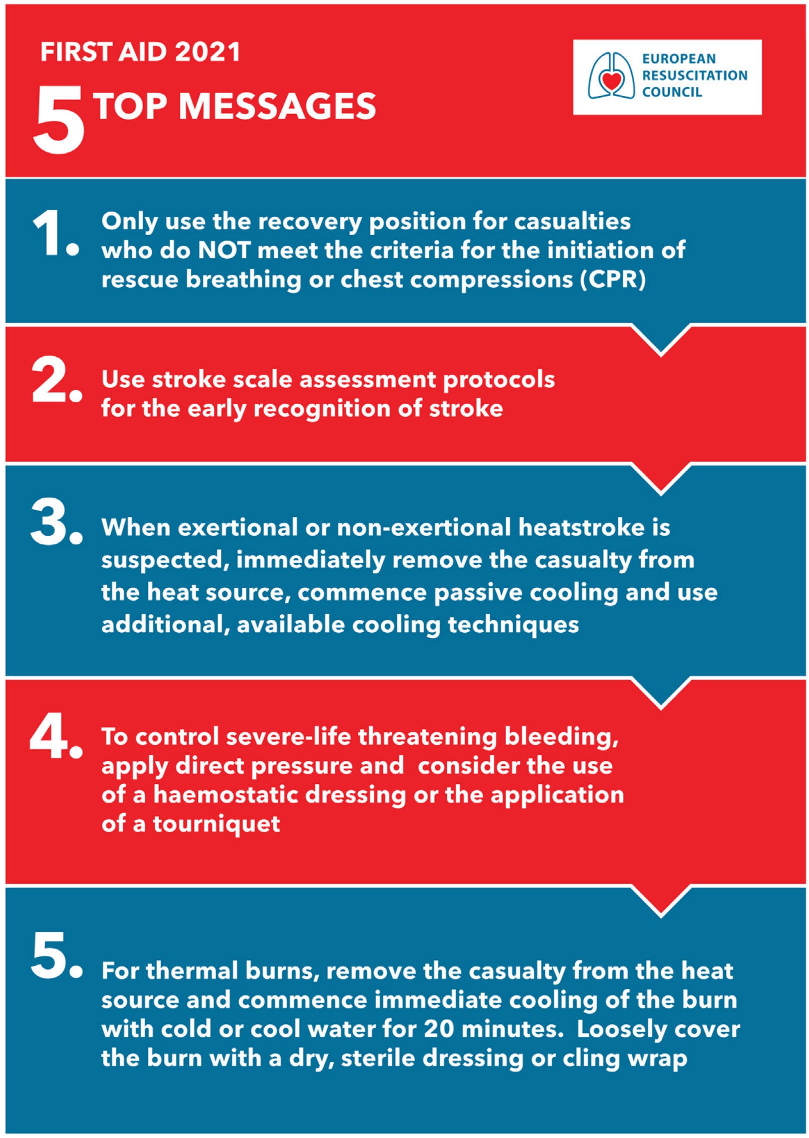

Fig. 12 – First Aid infographic summary.

- There is a relatively low risk of complications, particularly anaphylaxis and serious bleeding. Do not administer aspirin to adults with a known allergy to aspirin or contraindications such as severe asthma or known gastrointestinal bleeding.

Anaphylaxis

- The management of anaphylaxis has been described in Special Circumstances.
- If the symptoms of anaphylaxis do not resolve after 5 min of the first injection or, if the symptoms begin to return after the first dose, administer a second dose of adrenaline by intramuscular injection using an autoinjector.
- Call for help.
- Train first aid providers regularly in the recognition and first aid management of anaphylaxis.

Management of hypoglycaemia

- The signs of hypoglycaemia are sudden impaired consciousness: ranging from dizziness, fainting, sometimes nervousness and deviant behaviour (mood swings, aggression, confusion, loss of concentration, signs that look like drunkenness) to loss of consciousness.
- A person with mild hypoglycaemia typically has less severe signs or symptoms and has the preserved ability to swallow and follow commands.
- If hypoglycaemia is suspected in someone who has signs or symptoms of mild hypoglycaemia and is conscious and able to swallow:
  - Give glucose or dextrose tablets (15–20 g), by mouth
  - If glucose or dextrose tablets are not available give other dietary sugars in an equivalent amount to glucose, such as Skittles, Mentos, sugar cubes, jellybeans, or half a can of orange juice
  - Repeat the administration of sugar if the symptoms are still present and not improving after 15 min
  - If oral glucose is not available a glucose gel (partially held in the cheek, and partially swallowed) can be given
  - Call the emergency services if:

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- the casualty is or becomes unconscious
- the casualty's condition does not improve
  - Following recovery from the symptoms after taking the sugar, encourage taking a light snack such as a sandwich or a waffle
- For children who may be uncooperative with swallowing oral glucose:
  - Consider administering half a teaspoon of table sugar (2.5 gram) under the child's tongue.
- If possible, measure and record the blood sugar levels before and after treatment.

Oral rehydration solutions for treating exertion-related dehydration

- If a person has been sweating excessively during a sports performance and exhibits signs of dehydration such as feeling thirsty, dizzy or light-headed and/or having dry mouth or dark yellow and strong-smelling urine, give him/her 3–8% carbohydrate-electrolyte (CE) drinks (typical 'sports' rehydration drinks) or skimmed milk.
- If 3–8% CE drinks or milk are not available or not well tolerated, alternative beverages for rehydration include 0–3% CE drinks, 8–12% CE drinks or water.
- Clean water, in regulated quantities, is an acceptable alternative, although it may require a longer time to rehydrate.
- Avoid the use of alcoholic beverages.
- Call the emergency services if:
  - The person is or becomes unconscious
  - The person shows signs of a heat stroke.

Management of heat stroke by cooling

Recognise the symptoms and signs of heat stroke (in the presence of a high ambient temperature):

- Elevated temperature
- Confusion
- Agitation
- Disorientation
- Seizures
- Coma.

When a diagnosis of suspected exertional or classical heat stroke is made:

- Immediately remove casualty from the heat source and commence passive cooling
- Commence additional cooling using any technique immediately available
  - If the core temperature is above 40 °C commence whole body (neck down) cold water (1–26 °C) immersion until the core temperature falls below 39 °C
  - If water immersion is not possible use alternative methods of cooling e.g. ice sheets, commercial ice packs, fan alone, cold shower, hand cooling devices, cooling vests and jackets or evaporative cooling (mist and fan)
- Where possible measure the casualty's core temperature (rectal temperature measurement) which may require special training
- Casualties with exertional hyperthermia or non-exertional heatstroke will require advanced medical care and advance assistance should be sought.

It is recognised that the diagnosis and management of heat stroke requires special training (rectal temperature measurement, cold water immersion techniques). However, the recognition of the signs and symptoms of a raised core temperature and the use of active cooling techniques is critical in avoiding morbidity and mortality.

Use of supplemental oxygen in acute stroke

- Do not routinely administer supplemental oxygen in suspected acute stroke in the prehospital first aid setting.
- Oxygen should be administered if the individual is showing signs of hypoxia.
- Training is required for first aid providers in the provision of supplementary oxygen.

Management of presyncope

- Presyncope is characterised by light-headedness, nausea, sweating, black spots in front of the eyes and an impending sense of loss of consciousness.
- Ensure the casualty is safe and will not fall or injure themselves if they lose consciousness.
- Use simple physical counterpressure manoeuvres to abort presyncope of vasovagal or orthostatic origin.
- Lower body physical counterpressure manoeuvres are more effective than upper body manoeuvres.
  - Lower body – Squatting with or without leg crossing
  - Upper body – Hand clenching, neck flexion
- First aid providers will need to be trained in coaching casualties in how to perform physical counterpressure manoeuvres.

Control of life-threatening bleeding

Direct pressure, haemostatic dressings, pressure points and cryotherapy for life-threatening bleeding

- Apply direct manual pressure for the initial control of severe, life-threatening external bleeding.
- Consider the use of a haemostatic dressing when applying direct manual pressure for severe, life-threatening bleeding. Apply the haemostatic dressing directly to the bleeding injury and then apply direct manual pressure to the dressing.
- A pressure dressing may be useful once bleeding is controlled to maintain haemostasis but should not be used in lieu of direct manual pressure for uncontrolled bleeding.
- Use of pressure points or cold therapy is not recommended for the control of life-threatening bleeding.

Tourniquets for life-threatening bleeding

- For life-threatening bleeding from wounds on limbs in a location amenable to the use of a tourniquet (i.e. arm or leg wounds, traumatic amputations):
- Consider the application of a manufactured tourniquet as soon as possible:
- Place the tourniquet around the traumatised limb 5–7 cm above the wound but not over a joint
- Tighten the tourniquet until the bleeding slows and stops. This may be extremely painful for the casualty
- Maintain the tourniquet pressure
- Note the time the tourniquet was applied

- Do not release the tourniquet – the tourniquet must only be released by a healthcare professional
- Take the casualty to hospital immediately for further medical care
- In some cases, it may require the application of two tourniquets in parallel to slow or stop the bleeding.
- If a manufactured tourniquet is not immediately available, or if bleeding is uncontrolled with the use of a manufactured tourniquet, apply direct manual pressure, with a gloved hand, a gauze dressing, or if available, a haemostatic dressing.
- Consider the use of an improvised tourniquet only if a manufactured tourniquet is not available, direct manual pressure (gloved hand, gauze dressing or haemostatic dressing) fails to control life-threatening bleeding, and the first aid provider is trained in the use of improvised tourniquets.

Management of open chest wounds

- Leave an open chest wound exposed to freely communicate with the external environment.
- Do not apply a dressing or cover the wound.
- If necessary:
  - Control localised bleeding with direct pressure
  - Apply a specialised non-occlusive or vented dressing ensuring a free outflow of gas during expiration (training required).

Cervical spine motion restriction and stabilisation

- The routine application of a cervical collar by a first aid provider is not recommended.
- In a suspected cervical spine injury:
  - If the casualty is awake and alert, encourage them to self-maintain their neck in a stable position.
  - If the casualty is unconscious or uncooperative consider immobilising the neck using manual stabilisation techniques.
    - Head Squeeze:
      - With the casualty lying supine hold the casualty's head between your hands.
      - Position your hands so that the thumbs are above the casualty's ears and the other fingers are below the ear
      - Do not cover the ears so that the casualty can hear.
    - Trapezium Squeeze:
      - With the casualty lying supine hold the casualty's trapezius muscles on either side of the head with your hands (thumbs anterior to the trapezius muscle). In simple terms – hold the casualty's shoulders with the hands thumbs up
      - Firmly squeeze the head between the forearms with the forearms placed approximately at the level of the ears.

Recognition of concussion

- Although a simple single-stage concussion scoring system would greatly assist first aid providers' recognition and referral of victims of suspected head injury there is currently no such validated system in current practice.
- An individual with a suspected concussion must be evaluated by a healthcare professional.

Thermal burns

Following a thermal burn injury

- Immediately commence cooling the burn in cool or cold (not freezing) water
- Continue cooling the burn for at least 20 min
- Cover the wound with a loose sterile dressing or use cling wrap. Do not circumferentially wrap the wound
- Seek immediate medical care.

Care must be taken when cooling large thermal burns or burns in infants and small children so as not to induce hypothermia.

Dental avulsion

- If the casualty is bleeding from the avulsed tooth socket:
  - Put on disposable gloves prior to assisting the victim
  - Rinse out the casualty's mouth with cold, clean water
  - Control bleeding by:
    - Pressing a damp compress against the open tooth socket
    - Tell the casualty to bite on the damp compress
    - Do not do this if there is a high chance that the injured person will swallow the compress (for example, a small child, an agitated person or a person with impaired consciousness).
- If it is not possible to immediately replant the avulsed tooth at the place of accident:
  - Seek help from a specialist
    - Take the casualty and the avulsed tooth to seek expert help from a specialist.
  - Only touch an avulsed tooth at the crown. Do not touch the root
  - Rinse a visibly contaminated avulsed tooth for a maximum of 10 s with saline solution or under running tap water prior to transportation.
  - To transport the tooth:
    - Wrap the tooth in cling film or store the tooth temporarily in a small container with Hank's Balanced Salt solution (HBSS), propolis or Oral Rehydration Salt (ORS) solution
    - If none of the above are available, store the tooth in cow's milk (any form or fat percentage)
    - Avoid the use of tap water, buttermilk or saline (sodium chloride).

Compression wrap for closed extremity joint injuries

- If the casualty is experiencing pain in the joint and finds it difficult to move the affected joint, ask him/her not to move the limb. It is possible there is swelling or bruising on the injured joint.
- There is no evidence to support or not support the application of a compression wrap to any joint injury.
- Training will be required to correctly and effectively apply a compression wrap to a joint injury.

Straightening an angulated fracture

- Do not straighten an angulated long bone fracture.
- Protect the injured limb by splinting the fracture.
- Realignment of fractures should only be undertaken by those specifically trained to perform this procedure.

Eye injury from chemical exposure

- For an eye injury due to exposure to a chemical substance
- Immediately irrigate the contaminated eye using continuous, large volumes of clean water or normal saline for 10 to 20 min.
- Take care not to contaminate the unaffected eye.
- Refer the casualty for emergency health care professional review.
- It is advisable to wear gloves when treating eye injuries with unknown chemical substances and to carefully discard them when treatment has been completed.

Neonatal life support

The European Resuscitation Council has produced these newborn life support guidelines, which are based on the International Liaison Committee on Resuscitation 2020 Consensus on Science and Treatment Recommendations for Neonatal Life Support. The guidelines cover the management of the term and preterm infant. The topics covered include an algorithm to aid a logical approach to resuscitation of the newborn, factors before delivery, training and education, thermal control, management of the umbilical cord after birth, initial assessment and categorisation of the newborn infant, airway and breathing and circulation support, communication with parents, considerations when withholding and discontinuing support.

Key changes introduced with these guidelines relate to management of the umbilical cord, initial inflations and assisted ventilation, infants born through meconium-stained liquor air/Oxygen for preterm resuscitation, initial inflations and assisted ventilation, laryngeal mask use, oxygen use during chest compressions, vascular access, use of adrenaline, glucose during resuscitation and prognostication.

Key messages from this section are presented in Fig. 13 and the NLS algorithm is depicted in Fig. 14.

Factors before delivery

Transition and the need for assistance after birth

Most, but not all, infants adapt well to extra-uterine life but some require help with stabilisation, or resuscitation. Up to 85% breathe spontaneously without intervention; a further 10% respond after drying, stimulation and airway opening manoeuvres; approximately 5% receive positive pressure ventilation. Intubation rates vary between 0.4 and 2%. Fewer than 0.3% of infants receive chest compressions and only 0.05% receive adrenaline.

Risk factors

A number of risk factors have been identified as increasing the likelihood of requiring help with stabilisation, or resuscitation.

Staff attending delivery

Any infant may develop problems during birth. Local guidelines indicating who should attend deliveries should be developed, based on current understanding of best practice and clinical audit, and taking into account identified risk factors. As a guide,

- Personnel competent in newborn life support should be available for every delivery.
- If intervention is required, there should be personnel available whose sole responsibility is to care for the infant.
- A process should be in place for rapidly mobilising a team with sufficient resuscitation skills for any birth.

Equipment and environment

- All equipment must be regularly checked and ready for use.
- Where possible, the environment and equipment should be prepared in advance of the delivery of the infant. Checklists facilitate these tasks.
- Resuscitation should take place in a warm, well-illuminated, draught-free area with a flat resuscitation surface and a radiant heater (if available).
- Equipment to monitor the condition of the infant and to support ventilation should be immediately available.
- Additional equipment, that might be required in case of more prolonged resuscitation should be easily accessible.

Planned home deliveries

- Ideally, two trained professionals should be present at all home deliveries.
- At least one must be competent in providing mask ventilation and chest compressions to the newborn infant.
- Recommendations as to who should attend a planned home delivery vary from country to country, but the decision to undergo such a delivery, once agreed with medical and midwifery staff, should not compromise the standard of initial assessment, stabilisation or resuscitation at birth.
- There will inevitably be some limitations to the extent of the resuscitation of a newborn infant in the home, due to the distance from healthcare facilities and equipment available, and this must be made clear to the mother at the time plans for home delivery are made.
- When a birth takes place in a non-designated delivery area a minimum set of equipment of an appropriate size for the newborn infant should be available, including:
  - clean gloves for the attendant and assistants,
  - means of keeping the infant warm, such as heated dry towels and blankets,
  - a stethoscope to check the heart rate,
  - a device for safe assisted lung aeration and subsequent ventilation such as a self-inflating bag with appropriately sized facemask,
  - sterile instruments for clamping and then safely cutting the umbilical cord.
- Unexpected deliveries outside hospital are likely to involve emergency services who should be trained and prepared for such events and carry appropriate equipment.
- Caregivers undertaking home deliveries should have pre-defined plans for difficult situations.

Briefing

- If there is sufficient time, brief the team to clarify responsibilities, check equipment and plan the stabilisation, or resuscitation.
- Roles and tasks should be assigned – checklists are helpful.
- Prepare the family if it is anticipated that resuscitation might be required.

Training/education

- Newborn resuscitation providers must have relevant current knowledge, technical and non-technical skills.
- Institutions or clinical areas where deliveries may occur should have structured educational programmes, teaching the knowledge and skills required for newborn resuscitation.
- The content and organisation of such training programmes may vary according to the needs of the providers and the organisation of the institutions.
- Recommended programmes include:
  - regular practice and drills,
  - team and leadership training,
  - multi-modal approaches,
  - simulation-based training,
  - feedback on practice from different sources (including feedback devices),
  - objective, performance focused debriefings.

Fig. 13 – NLS infographic summary.

- Ideally, training should be repeated more frequently than once per year.
- Updates may include specific tasks, simulation and/or behavioural skills and reflection.

Thermal control

- The infant's temperature should be regularly monitored after birth and the admission temperature should be recorded as a prognostic and quality indicator.
- The temperature of newborn infants should be maintained between 36.5 °C and 37.5 °C.
- Hypothermia (≤36.0 °C) and hyperthermia (>38.0 °C) should be avoided. In appropriate circumstances, therapeutic hypothermia may be considered after resuscitation (see post-resuscitation care)

Environmental

- Protect the infant from draughts. Ensure windows are closed and air-conditioning appropriately programmed.
- Keep the environment in which the infant is looked after (e.g. delivery room or theatre) warm at 23–25 °C.
- For infants ≤28 weeks gestation the delivery room or theatre temperature should be >25 °C.

Term and near-term infants >32 weeks gestation

- Dry the infant immediately after delivery. Cover the head and body of the infant, apart from the face, with a warm and dry towel to prevent further heat loss.
- If no resuscitation is required place the infant skin-to-skin with mother and cover both with a towel. On-going careful observation of mother and infant will be required especially in more preterm and growth restricted infants to ensure they both remain normothermic.
- If the infant needs support with transition or when resuscitation is required, place the infant on a warm surface using a preheated radiant warmer.

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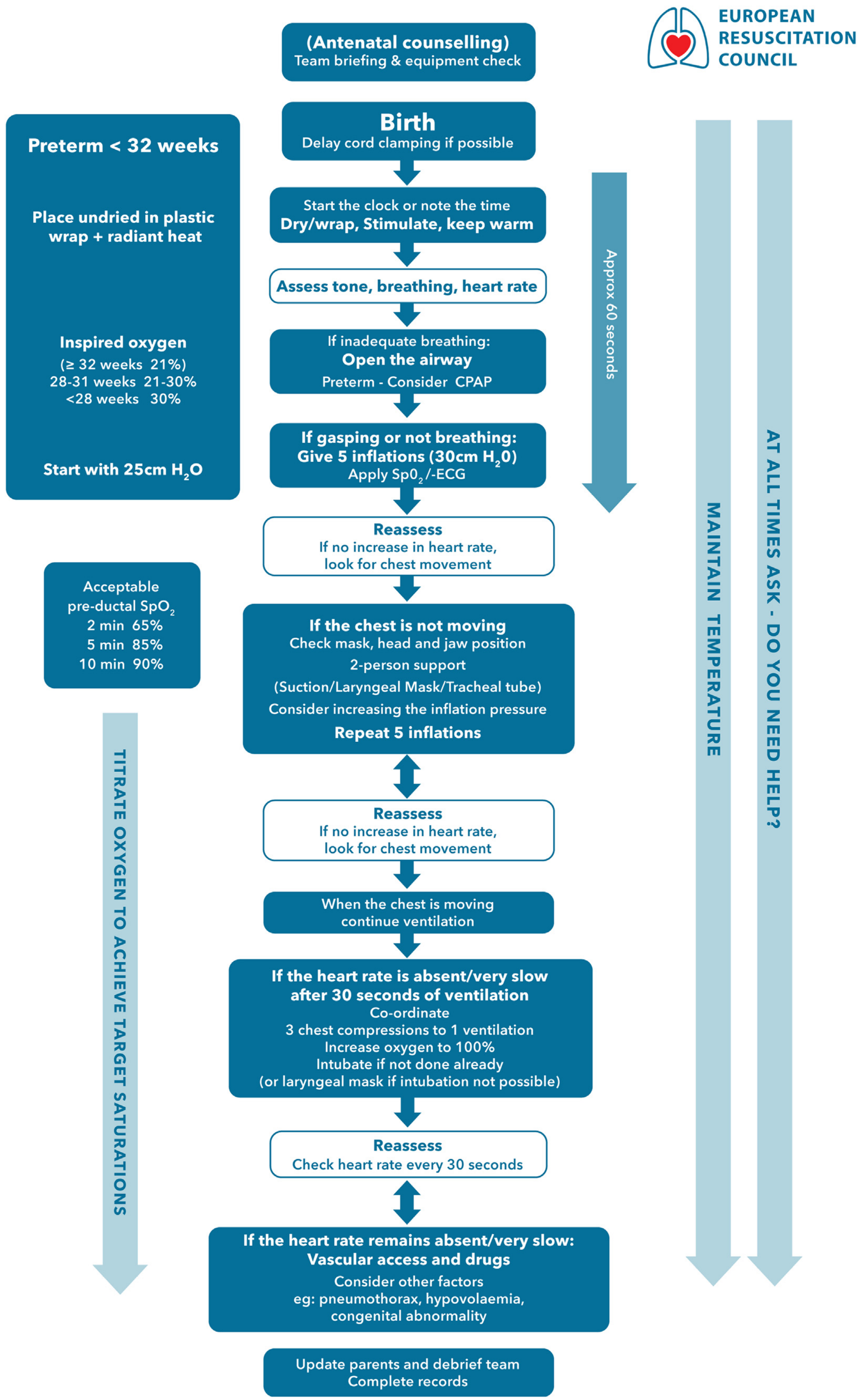

Fig. 14 – NLS algorithm.

Preterm infants ≤32 weeks gestation

- Completely cover with polyethylene wrapping (apart from face) without drying and use a radiant warmer.
- If umbilical cord clamping is delayed and a radiant warmer is not accessible at this point, other measures (such as those listed below) will be needed to ensure thermal stability while still attached to the placenta.
- A combination of further interventions may be required in infants ≤32 weeks including increased room temperature, warm blankets, head cap and thermal mattress.
- Skin-to-skin care is feasible in less mature infants however caution is required in the more preterm or growth restricted infant in order to avoid hypothermia.
- For infants receiving respiratory support, use of warmed humidified respiratory gases should be considered.
- A quality improvement programme including the use of checklists and continuous feedback to the team has been shown to significantly reduce hypothermia at admission in very preterm infants.

Out of hospital management

- Infants born unexpectedly outside a normal delivery environment are at higher risk of hypothermia and subsequent poorer outcomes.
- They may benefit from placement in a food grade plastic bag after drying and then swaddling. Alternatively, well newborns >30 weeks gestation may be dried and nursed skin-to-skin to maintain their temperature whilst they are transferred as long as mothers are normothermic. Infants should be covered and protected from draughts and watched carefully to avoid hypothermia and ensure airway and breathing are not compromised.

Management of the umbilical cord after birth

- The options for managing cord clamping and the rationale should be discussed with parents before birth.
- Where immediate resuscitation or stabilisation is not required, aim to delay clamping the cord for at least 60 s. A longer period may be more beneficial.
- Clamping should ideally take place after the lungs are aerated.
- Where adequate thermal care and initial resuscitation interventions can be safely undertaken with the cord intact it may be possible to delay clamping whilst performing these interventions.
- Where delayed cord clamping is not possible consider cord milking in infants >28 weeks gestation.

Initial assessment

May occur before the umbilical cord is clamped and cut (typically performed in this order):

- Observe Tone (& Colour)
- Assess adequacy of **Breathing**
- Assess the **Heart Rate**
- Take appropriate action to keep the baby warm during these initial steps.
- This rapid assessment serves to establish a baseline, identify the need for support and/or resuscitation and the appropriateness and duration of delaying umbilical cord clamping.
- Frequent re-assessment of heart rate and breathing indicates whether the infant is adequately transitioning or whether further interventions are needed.

Tactile stimulation

Initial handling is an opportunity to stimulate the infant during assessment by

- Drying the infant.
- Gently stimulating the infant as you dry them, for example by rubbing the soles of the feet or the back of the chest. Avoid more aggressive methods of stimulation.

Tone & colour

- A very floppy infant is likely to need ventilatory support.
- Colour is a poor means of judging oxygenation. Cyanosis can be difficult to recognise. Pallor might indicate shock or rarely hypovolaemia – consider blood loss and plan appropriate intervention.

Breathing

- Is the infant breathing? – Note the rate, depth and symmetry, work/effort of breathing as
  - Adequate
  - Inadequate/abnormal pattern – such as gasping or grunting
  - Absent

Heart rate

Determine the heart rate with a stethoscope and a saturation monitor ± ECG (electrocardiogram) for later continuous assessment.

- Fast (≥100 min−1) – satisfactory
- Slow (60−100 min−1) – intermediate, possible hypoxia
- Very slow/absent (<60 min−1) – critical, hypoxia likely

If the infant fails to establish spontaneous and effective breathing following assessment and stimulation, and/or the heart rate does not increase (and/or decreases) if initially fast, respiratory support should be started.

Classification according to initial assessment

On the basis of the initial assessment, the infant can usually be placed into one of three groups as the following examples illustrate.

1.
Good tone
Vigorous breathing or crying
Heart rate – fast (≥100 min^{-1})

Assessment: *Satisfactory transition* – Breathing does not require support. Heart rate is acceptable.

Actions:

- Delay cord clamping.
- Dry, wrap in warm towel.
- Keep with mother or carer and ensure maintenance of temperature.
- Consider early skin-to-skin care if stable.

2.
Reduced tone
Breathing inadequately (or apnoeic)
Heart rate – slow (<100 min^{-1})

Assessment: *Incomplete transition* – Breathing requires support, slow heart rate may indicate hypoxia.

Actions:

- Delay cord clamping only if you are able to appropriately support the infant.
- Dry, stimulate, wrap in a warm towel.
- Maintain the airway, – lung inflation and ventilation.
- Continuously assess changes in heart rate and breathing
- If no improvement in heart rate, continue with ventilation.
- Help may be required.

3.
Floppy ± Pale
Breathing inadequately or apnoeic
Heart rate – very slow ($<60\,min^{-1}$) or undetectable

Assessment: *Poor/Failed transition* – Breathing requires support, heart rate suggestive of significant hypoxia

Actions:

- Clamp cord immediately and transfer to the resuscitation platform. Delay cord clamping only if you are able to appropriately support/resuscitate the infant.
- Dry, stimulate, wrap in warm towel.
- Maintain the airway – lung inflation and ventilation.
- Continuously assess heart rate, breathing, and effect of ventilation.
- Continue newborn life support according to response.
- Help is likely to be required.

Preterm infants

- Same principles apply.
- Consider alternative/additional methods for thermal care e.g. polyethylene wrap.
- Gently support, initially with CPAP if breathing.
- Consider continuous rather than intermittent monitoring (pulse oximetry ± ECG)

Newborn life support

Following initial assessment and intervention, continue respiratory support if:

- The infant has not established adequate, regular breathing, or
- The heart rate is $<100\,min^{-1}$.

Ensuring an open airway, aerating and ventilating the lungs is usually all that is necessary. Without these, other interventions will be unsuccessful.

Airway

Commence life support if initial assessment shows that the infant has not established adequate regular normal breathing, or has a heart rate $<100\,min^{-1}$

Establishing and maintaining an open airway is essential to achieve postnatal transition and spontaneous breathing, or for further resuscitative actions to be effective.

Techniques to help open the airway

- Place the infant on their back with the head supported in a neutral position.
- In floppy infants, pulling the jaw forwards (jaw lift) may be essential in opening and/or maintaining the airway and reducing mask leak. When using a facemask, two person methods of airway support are superior and permit true jaw thrust to be applied.
- An oropharyngeal airway may be useful in term infants when having difficulty providing both jaw lift and ventilation, or where the upper airway is obstructed, for instance in those with micrognathia. However, oropharyngeal airways should be used with caution in infants ≤34 weeks gestation as they may increase airway obstruction.
- A nasopharyngeal airway may also be considered where there is difficulty maintaining an airway and mask support fails to achieve adequate aeration.

Airway obstruction

- Airway obstruction can be caused by inappropriate positioning, decreased airway tone and/or laryngeal adduction, especially in preterm infants at birth.
- Suction is only required if airway obstruction due to mucus, vernix, meconium, blood clots, etc. is confirmed through inspection of the pharynx after failure to achieve aeration.
- Any suctioning should be undertaken under direct vision, ideally using a laryngoscope and a wide bore catheter.

Meconium

- Non-vigorous newborn infants delivered through meconium-stained amniotic fluid are at significant risk for requiring advanced resuscitation and a neonatal team competent in advanced resuscitation may be required.
- Routine suctioning of the airway of non-vigorous infants is likely to delay initiating ventilation and is not recommended. In the absence of evidence of benefit for suctioning, the emphasis must be on initiating ventilation as soon as possible in apnoeic or ineffectively breathing infants born through meconium-stained amniotic fluid.
- Should initial attempts at aeration and ventilation be unsuccessful then physical obstruction may be the cause. In this case inspection and suction under direct vision be considered. Rarely, an infant may require tracheal intubation and tracheal suctioning to relieve airway obstruction.

Initial inflations and assisted ventilation

Lung Inflation

- If apnoeic, gasping or not breathing effectively, aim to start positive pressure ventilation as soon as possible – ideally within 60s of birth.
- Apply an appropriately fitting facemask connected to a means of providing positive pressure ventilation, ensuring a a good seal between mask and face.
- Give five "inflations" maintaining the inflation pressure for up to 2–3 s.
- Provide initial inflation pressures of 30 cm H_2O for term infants commencing with air. Start with 25 cm H_2O for preterm infants ≤32 weeks using 21–30% inspired oxygen (see 'air/oxygen').

Assessment

- Check the heart rate
  - An increase (within 30 s) in heart rate, or a stable heart rate if initially high, confirms adequate ventilation/oxygenation.
  - A slow or very slow heart rate usually suggests continued hypoxia and almost always indicates inadequate ventilation.
- Check for chest movement
  - Visible chest movement with inflations indicates a patent airway and delivered volume.

  - Failure of the chest to move may indicate obstruction of the airway, or insufficient inflation pressure and delivered volume to aerate the lungs.

Ventilation

If there is a heart rate response

- Continue uninterrupted ventilation until the infant begins to breathe adequately and the heart rate is above 100 min^{-1}.
- Aim for about 30 breaths min^{-1} with an inflation time of under 1 s.
- Reduce the inflation pressure if the chest is moving well.
- Reassess heart rate and breathing at least every 30 s.
- Consider a more secure airway (laryngeal mask/tracheal tube) if apnoea continues or if mask ventilation is not effective.

Failure to respond

If there is *no* heart rate response *and* the chest is not moving with inflations

- Check if the equipment is working properly.
- Recheck the head-position and jaw lift/thrust
- Recheck mask size, position and seal.
- Consider other airway manoeuvres:
  - 2-person mask support if single handed initially.
  - Inspection of the pharynx and suction under direct vision to remove obstructing foreign matter if present.
  - Securing the airway via tracheal intubation or insertion of a laryngeal mask.
  - Insertion of an oropharyngeal/nasopharyngeal airway if unable to secure the airway with other means.
- Consider a gradual increase in inflation pressure.
- If being used, check on a respiratory function monitor that expired tidal volume is not too low or too high (target about 5 to 8 mL kg^{-1}).

Then:

- Repeat inflations.
- Continuously assess heart rate and chest movement.

If the insertion of a laryngeal mask or tracheal intubation is considered, it must be undertaken by personnel competent in the procedure with appropriate equipment. Otherwise continue with mask ventilation and call for help.

Without adequate lung aeration, chest compressions will be ineffective; therefore, where the heart rate remains very slow, confirm effective ventilation through observed chest movement or other measures of respiratory function before progressing to chest compressions.

Airway adjuncts, assisted ventilation devices, PEEP and CPAP

Continuous positive airway pressure (CPAP) & Positive end expiratory pressure (PEEP)

- In spontaneously breathing *preterm* infants consider CPAP as the initial method of breathing support after delivery – using either mask or nasal prongs.
- If equipment permits, apply PEEP at minimum of 5–6 cm H_2O when providing positive pressure ventilation (PPV) to these infants.

Assisted ventilation devices

- Ensure a facemask of appropriate size is used to provide a good seal between mask and face.
- Where possible use a T-piece resuscitator (TPR) capable of providing either CPAP or PPV with PEEP when providing ventilatory support, especially in the preterm infant.
- Nasal prongs of appropriate size may be a viable CPAP alternative to facemasks.
- If a self-inflating bag is used it should be of sufficient volume to deliver an adequate inflation. Care should be taken not to deliver an excessive volume. The self-inflating bag cannot deliver CPAP effectively.

Laryngeal mask

- Consider using a laryngeal mask
  - In infants of ≥34 weeks gestation (about 2000 g) – although some devices have been used successfully in infants down to 1500 g.
  - If there are problems with establishing effective ventilation with a facemask.
  - Where intubation is not possible or deemed unsafe because of congenital abnormality, a lack of equipment, or a lack of skill.
  - Or as an alternative to tracheal intubation as a secondary airway.

Tracheal tube

- Tracheal intubation may be considered at several points during neonatal resuscitation:
  - When ventilation is ineffective after correction of mask technique and/or the infant's head position, and/or increasing inspiratory pressure with TPR or bag-mask.
  - Where ventilation is prolonged, in order to establish a more secure airway.
  - When suctioning the lower airways to remove a presumed tracheal blockage.
  - When chest compressions are performed.
  - In special circumstances (e.g., congenital diaphragmatic hernia or to give surfactant).
- Exhaled CO_2 detection should be used when undertaking intubation to confirm tube placement in the airway.
- A range of differing sized tracheal tubes should be available to permit placement of the most appropriate size to ensure adequate ventilation with minimal leak and trauma to the airway.
- Respiratory function monitoring may also help confirm tracheal tube position and adequate ventilation through demonstrating adequate expired tidal volume (about 5 to 8 mL kg^{-1}) and minimal leak.
- The use of a video laryngoscope may aid tube placement.
- If retained, the position of the tracheal tube should be confirmed by radiography.

Air/Oxygen

- Pulse-oximetry and oxygen blenders should be used during resuscitation in the delivery room.
- Aim to achieve target oxygen saturation above the 25th percentile for healthy term infants in the first 5 min after birth.
- If, despite effective ventilation, there is no increase in heart rate, or saturations remain low, increase the oxygen concentration to achieve adequate preductal oxygen saturations.
- Check the delivered inspired oxygen concentration and saturations frequently (e.g. every 30 s) and titrate to avoid both hypoxia and hyperoxia.

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- wean the inspired oxygen if saturations >95% in preterms.

Term and late preterm infants 35 weeks

In infants receiving respiratory support at birth, begin with air (21%).

Preterm infants <35 weeks

- Resuscitation should be initiated in air or a low inspired oxygen concentration based on gestational age:
  - ≥32 weeks 21%
  - 28–31 weeks 21–30%
  - <28 weeks 30%

- In infants <32 weeks gestation the target should be to avoid an oxygen saturation below 80% and/or bradycardia at 5 min of age. Both are associated with poor outcome.

Chest compressions

Assessment of the need for chest compressions

- If the heart rate remains very slow (<60 min^{-1}) or absent after 30 s of good quality ventilation, start chest compressions.
- When starting compressions:
  - Increase the delivered inspired oxygen to 100%.
  - Call for experienced help if not already summoned.

Delivery of chest compressions

- Use a synchronous technique, providing three compressions to one ventilation at about 15 cycles every 30 s.
- Use a two-handed technique for compressions if possible.
- Re-evaluate the response every 30 s.
- If the heart rate remains very slow or absent, continue ventilation and chest compressions but ensure that the airway is secured (e.g. intubate the trachea if competent and not done already).
- Titrate the delivered inspired oxygen against oxygen saturation if a reliable value is achieved on the pulse oximeter.

Consider

- Vascular access and drugs.

Vascular access

During the resuscitation of a compromised infant at birth peripheral venous access is likely to be difficult and suboptimal for vasopressor administration.

Umbilical venous access

- The umbilical vein offers rapid vascular access in newborn infants and should be considered the primary method during resuscitation.
- Ensure a closed system to prevent air embolism during insertion should the infant gasp and generate sufficient negative pressure.
- Confirm position in a blood vessel through aspiration of blood prior to administering drugs/fluids.
- Clean, rather than sterile, access technique may be sufficient in an emergency.
- The umbilical route may still be achievable some days after birth and should be considered in cases of postnatal collapse.

Intraosseous access

- Intraosseous (IO) access can be an alternative method of emergency access for drugs/fluids.

Support of transition/post-resuscitation care

- If venous access is required following resuscitation, peripheral access may be adequate unless multiple infusions are required in which case central access may be preferred.
- IO access may be sufficient in the short term if no other site is available.

Drugs

During active resuscitation

Drugs are rarely required during newborn resuscitation and the evidence for the efficacy of any drug is limited. The following may be considered during resuscitation where, despite adequate control of the airway, effective ventilation and chest compressions for 30 s, there is an inadequate response and the HR remains below 60 min^{-1}.

Adrenaline

- When effective ventilation and chest compressions have failed to increase the heart rate above 60 min−1
- Intravenous or intraosseous is the preferred route:
  - At a dose of 10–30 μg kg^{-1} (0.1–0.3 mL kg^{-1} of 1:10,000 adrenaline [1000 μg in 10 mL]).
- Intra-tracheally if intubated and no other access available.
  - At a dose of 50–100 μg kg^{-1}.

Subsequent doses every 3–5 min if heart rate remains < 60 min^{-1}.

Glucose

- In a prolonged resuscitation to reduce likelihood of hypoglycaemia.
- Intravenous or intraosseous:
  - 250 mg kg^{-1} bolus (2.5 mL kg^{-1} of 10% glucose solution).

Volume replacement

- With suspected blood loss or shock unresponsive to other resuscitative measures.
- Intravenous or intraosseous:
  - 10 mL kg^{-1} of group O Rh-negative blood or isotonic crystalloid.

Sodium bicarbonate

- May be considered in a prolonged unresponsive resuscitation with adequate ventilation to reverse intracardiac acidosis.
- Intravenous or intraosseous:
  - 1–2 mmol kg^{-1} sodium bicarbonate (2–4 mL kg^{-1} of 4.2% solution) by slow intravenous injection.

In situations of persistent apnoea

Naloxone

- Intramuscular
  - An initial 200 μg dose may help in the few infants who, despite resuscitation, remain apnoeic with good cardiac output when

the mother is known to have received opiods in labour. Effects may be transient so continued monitoring of respiration is important.

In the absence of an adequate response

Consider other factors which may be impacting on the response to resuscitation and which require addressing such as the presence of pneumothorax, hypovolaemia, congenital abnormalities, equipment failure, etc.

Post-resuscitation care

Infants who have required resuscitation may later deteriorate. Once adequate ventilation and circulation are established, the infant should be cared cared for in, or transferred to, an environment in which close monitoring and anticipatory care can be provided.

Glucose

- Monitor glucose levels carefully after resuscitation.
- Have protocols/guidance on the management of unstable glucose levels.
- Avoid hyper- and hypoglycaemia.
- Avoid large swings in glucose concentration.
- Consider the use of a glucose infusion to avoid hypoglycaemia.

Thermal care

- Aim to keep the temperature between 36.5 °C and 37.5 °C.
- Rewarm if the temperature falls below this level and there are no indications to consider therapeutic hypothermia (see below).

Therapeutic hypothermia

- Once resuscitated, consider inducing hypothermia to 33–34 °C in situations where there is clinical and/or biochemical evidence of significant risk of moderate or severe HIE (hypoxic-ischaemic encephalopathy).
- Ensure the evidence to justify treatment is clearly documented; include cord blood gases, and neurological examination.
- Arrange safe transfer to a facility where monitoring and treatment can be continued.
- Inappropriate application of therapeutic hypothermia, without concern about a diagnosis of HIE, is likely to be harmful (see temperature maintenance).

Prognosis (documentation)

Ensure clinical records allow accurate retrospective time based evaluation of the clinical state of the infant at birth, any interventions and the response during the resuscitation to facilitate any review and the subsequent application of any prognostic tool.

Communication with the parents

Where intervention is anticipated

- Whenever possible, the decision to attempt resuscitation of an extremely preterm or clinically complex infant should be taken in close consultation with the parents and senior paediatric, midwifery and obstetric staff.
- Discuss the options including the potential need and magnitude of resuscitation and the prognosis before delivery in order to develop an agreed plan for the birth.
- Record carefully all discussions and decisions in the mother's notes prior to delivery and in the infant's records after birth.

For every birth

- Where intervention is required it is reasonable for mothers/fathers/partners to be present during the resuscitation where circumstances, facilities and parental inclination allow.
- The views of both the team leading the resuscitation and the parents must be taken into account in decisions on parental attendance.
- Irrespective of whether the parents are present at the resuscitation, ensure wherever possible, that they are informed of the progress of the care provided to their infant.
- Witnessing the resuscitation of their infant may be distressing for parents. If possible, identify a member of healthcare staff to support them to keep them informed as much as possible during the resuscitation.
- Allow parents to hold or even better to have skin-to-skin contact with their infant as soon as possible after delivery or resuscitation, even if unsuccessful.
- Provide an explanation of any procedures and why they were required as soon as possible after the delivery.
- Ensure a record is kept of events and any subsequent conversations with parents.
- Allow for further discussions at a later time to allow parents to reflect and to aid parental understanding of events.
- Consider what additional support is required for parents following delivery and any resuscitation.

Withholding and discontinuing resuscitation

-

Any recommendations must be interpreted in the light of current national/regional outcomes.

- When discontinuing, withdrawing or withholding resuscitation, care should be focused on the comfort and dignity of the infant and family.
- Such decisions should ideally involve senior paediatric staff.

Discontinuing resuscitation

- National committees may provide locally appropriate recommendations for stopping resuscitation.
- When the heart rate has been undetectable for longer than 10 min after delivery review clinical factors (for example gestation of the infant, or presence/absence of dysmorphic features), effectiveness of resuscitation, and the views of other members of the clinical team about continuing resuscitation.
- If the heart rate of a newborn term infant remains undetectable for more than 20 min after birth despite the provision of all recommended steps of resuscitation and exclusion of reversible causes, consider stopping resuscitation.
- Where there is partial or incomplete heart rate improvement despite apparently adequate resuscitative efforts, the choice is much less clear. It may be appropriate to take the infant to the intensive care unit and consider withdrawing life-sustaining treatment if they do not improve.

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- Where life-sustaining treatment is withheld or withdrawn, infants should be provided with appropriate palliative (comfort focused) care.

Withholding resuscitation

- Decisions about withholding life-sustaining treatment should usually be made only after discussion with parents in the light of regional or national evidence on outcome if resuscitation and active (survival focused) treatment is attempted.
- In situations where there is extremely high (>90%) predicted neonatal mortality and unacceptably high morbidity in surviving infants, attempted resuscitation and active (survival focused) management is usually not appropriate.
- Resuscitation is nearly always indicated in conditions associated with a high (>50%) survival rate and what is deemed to be acceptable morbidity. This will include most infants with gestational age of 24 weeks or above (unless there is evidence of foetal compromise such as intrauterine infection or hypoxia-ischaemia) and most infants with congenital malformations. Resuscitation should also usually be commenced in situations where there is uncertainty about outcome and there has been no chance to have prior discussions with parents.
- In conditions where there is low survival (<50%) and a high rate of morbidity, and where the anticipated burden of medical treatment for the child is high, parental wishes regarding resuscitation should be sought and usually supported.

Paediatric life support

These European Resuscitation Council Paediatric Life Support (PLS) guidelines, are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. This section provides guidelines on the management of critically ill infants and children, before, during and after cardiac arrest.

There are relatively few major changes introduced in these guidelines compared to our guidelines in 2015. Key points to note include: PLS guidelines apply to all children, aged 0–18 years, except for 'newborns at birth'. Patients who look adult can be treated as an adult. Oxygen therapy should be titrated to an SpO2 of 94–98%. Until titration is possible, in children with signs of circulatory/respiratory failure where SpO2 (or paO2) is impossible to measure, we advise to start high flow oxygen. For children with circulatory failure, give 1 or more fluid bolus(es) of 10 ml/kg. Reassess after each bolus to avoid fluid overload. Start vasoactive drugs early. Limit crystalloid boluses and as soon as available give blood products (whole blood or packed red cells with plasma and platelets) in case of haemorrhagic shock. Any person trained in paediatric BLS should use the specific PBLS algorithm. For PBLS providers, immediately after the 5 rescue breaths, proceed with chest compressions – unless there are clear signs of circulation. Single rescuers should first call for help (speakerphone) before proceeding. In case of sudden witnessed collapse, they should also try to apply an AED if easily accessible. If they have no phone available, they should perform 1 min of CPR before interrupting CPR. A single PBLS provider can use either a two-thumb encircling or a two-finger technique for infant chest compression. For PALS providers, we emphasise even more the importance of actively searching for (and treating) reversible causes. 2-Person bag-mask ventilation is the first line ventilatory support during CPR for all competent providers. Only if a patient is intubated, we advise asynchronous ventilation and this at an age-appropriate rate (10–25/'). For PALS providers, when in doubt, consider the rhythm to be shockable.

Key messages from this section are presented in Fig. 15.

Recognition and management of critically ill children

Assessment of the seriously ill or injured child

- Use the Paediatric Assessment Triangle or a similar 'quick-look' tool for the early recognition of a child in danger.
- Follow the ABCDE approach
  - Perform the necessary interventions at each step of the assessment as abnormalities are identified.
  - Repeat your evaluation after any intervention or when in doubt.
- A is for Airway – establish and maintain airway patency.
- B is for Breathing – check
  - Respiratory rate (see Table 3; trends are more informative than single readings)
  - Work of breathing, e.g. retractions, grunting, nasal flaring . . .
  - Tidal volume (TV) – air entry clinically (chest expansion; quality of cry) or by auscultation
  - Oxygenation (colour, pulse oximetry). Be aware that hypoxaemia can occur without other obvious clinical signs.
  - Consider capnography
  - Consider thoracic ultrasound
- C is for Circulation – check
  - Pulse rate (see Table 4; trends are more informative than single readings)
  - Pulse volume
  - Peripheral & end-organ circulation: capillary refill time (CRT), urinary output, level of consciousness. Be aware that CRT is not very sensitive. A normal CRT should not reassure providers.
  - Preload evaluation: jugular veins, liver span, crepitations
  - Blood Pressure (see Table 5)
  - Consider serial lactate measurements
  - Consider point-of-care cardiac ultrasound
- D is for Disability – check
  - Conscious level using the AVPU (Alert-Verbal-Pain-Unresponsive) score, (paediatric) Glasgow Coma Scale (GCS) total score, or the GCS motor score. AVPU score of P or less, a Glasgow motor score of 4 and total GCS score of 8 or less define a level of consciousness where airway reflexes are unlikely to be preserved.
  - Pupil size, symmetry, and reactivity to light.
  - Presence of posturing or focal signs.
  - Recognise seizures as a neurological emergency.
  - Check blood glucose if altered consciousness and/or potential hypoglycaemia.
  - Sudden unexplained neurological symptoms, particularly those persisting after resuscitation, warrant urgent neuroimaging.

Management of the seriously ill or injured child

Whilst ABCDE is described in a stepwise manner, in practice, interventions are best carried out by multiple team members acting in parallel in a coordinated manner. Teamwork is important in the management of any seriously ill or injured child.

Key components of teamwork include:

- Anticipate: what to expect, allocate tasks . . .
- Prepare: materials, checklists to support decision making, patient data . . .

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Fig. 15 – PLS infographic summary.

- Choreography: where to stand, how to access the child, effective team size.
- Communicate: both verbal, and non-verbal. Use closed-loop communication and standardised communication elements (e.g. to count compression pauses, plan patient transfers). Keep non-essential communications 'as low as reasonably practicable'. Ensure a low-stress working environment. Implement a culture that strongly condemns inappropriate behaviour, be it from colleagues or family.
- Interact: Team members have pre-defined roles as per protocol and perform tasks in parallel. The team-leader (clearly recognisable) monitors team performance, prioritises tasks to achieve common goals and keeps the whole team informed. Hands-off leadership is preferred, if feasible. Shared situational awareness is considered crucial.

We describe below the 'first-hour' management of different life- or organ-threatening emergencies in children, each of them potentially leading to cardiac arrest if not properly treated. Quite often children will present with a combination of problems that demand a far more individualised approach. Treatment recommendations in children often differ from those in adults but will also differ between children of different age and weight. To estimate a child's weight, either rely on the parents or caretakers or use a length-based method, ideally corrected for body-habitus (e.g. Pawper MAC). Use, whenever possible,

Table 3 – Normal values for age: respiratory rate.

Respiratory rate for age	1 month	1 year	2 year	5 year	10 year
Upper limit of normal range	60	50	40	30	25
Lower limit of normal range	25	20	18	17	14

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Table 4 – Normal values for age: heart rate.

Heart rate for age	1 month	1 year	2 year	5 year	10 year
Upper limit of normal range	180	170	160	140	120
Lower limit of normal range	110	100	90	70	60

Table 5 – Normal values for age: systolic and mean arterial blood pressure (MAP). Fifth (p5) and fiftieth (p50) percentile for age.

Blood pressure for age	1 month	1 year	5 year	10 year
p50 for Systolic BP	75	95	100	110
p5 for Systolic BP	50	70	75	80
p50 for MAP	55	70	75	75
p5 for MAP	40	50	55	55

decision aids providing pre-calculated dose advice for emergency drugs and materials.

Management of respiratory failure: general approach (AB)

The transition from a compensatory state to decompensation may occur unpredictably. Therefore, any child at risk should be monitored to enable early detection and correction of any deterioration in their physiology. *Most airway procedures are considered aerosol-generating and thus require proper (risk-adjusted) personal protection equipment (PPE) in cases of presumed transmittable diseases.*

- Open the airway and keep it patent using
  - Adequate head and body alignment,
  - Head tilt – chin lift or jaw thrust,
  - Careful suctioning of secretions.

  Awake children will likely assume their own optimal position.
  - Consider oropharyngeal airway in the unconscious child, in whom there is no gag reflex.
    - Use the appropriate size (as measured from the central incisors to the angle of the mandible) and avoid pushing the tongue backward during insertion.
  - Consider nasopharyngeal airway in the semi-conscious child
    - Avoid if there is a suspicion of a basal skull fracture or of coagulopathy.
    - The correct insertion depth should be sized from the nostrils to the tragus of the ear.
- In children with a tracheostomy,
  - Check patency of the tracheostomy tube and suctioning if needed.
  - In case of suspected blockage that cannot be solved by suctioning, immediately remove the tracheostomy tube, and insert a new one. If this is not possible, providers should have a (pre-defined) emergency plan for airway reestablishment.
- To support oxygenation, consider supplemental oxygen and/or positive end-expiratory pressure (PEEP).
  - Where it is possible to accurately measure SpO2 (or partial oxygen pressure (PaO2)): start oxygen therapy if SpO 2 < 94%. The goal is to reach an SpO2 of 94% or above, with as little supplemental FiO2 (fraction of inspired oxygen) as possible. Sustained SpO2 readings of 100% should generally be avoided (except for instance in pulmonary hypertension, CO intoxication). Do not give pre-emptive oxygen therapy in children without signs of or immediate risk for hypoxaemia or shock. Specific recommendations exist for children with certain chronic conditions.
  - Where it is impossible to accurately measure SpO2 or PaO2: start oxygen therapy at high FiO2, based upon clinical signs of circulatory or respiratory failure, and titrate oxygen therapy as soon as SpO2 and/or PaO2 become available.
  - Where possible, competent providers should consider either high-flow nasal cannula (HFNC) or non-invasive ventilation (NIV) in children with respiratory failure and hypoxaemia not responding to low-flow oxygen.
  - Tracheal intubation and subsequent mechanical ventilation enable secure delivery of FiO2 and PEEP. The decision to intubate should be balanced against the existing risks of the procedure and the available resources (see below).
  - In hypoxaemic children despite high PEEP (>10) and standard optimisation measures, consider permissive hypoxaemia (oxygenation goal lowered to SpO2 88–92%).
- To support ventilation, adjust respiratory rate (and expiratory time) and/or tidal volume [TV] according to age.
  - Use a TV of 6 to 8 ml/kg IBW (ideal body weight), considering among others physiological and apparatus dead space (especially in younger children). Apparatus dead space should be minimalised. Look for normal chest rise. Avoid hyperinflation, as well as hypoventilation. Aim for normocapnia. Seek early expert help.
  - In acute lung injury, consider permissive hypercapnia (pH > 7.2), thus avoiding overly aggressive ventilation. Permissive hypercapnia is not recommended in pulmonary hypertension or severe traumatic brain injury [TBI].
  - Only use ETCO2 or venous partial carbon dioxide pressure (PvCO2) as a surrogate for arterial PaCO2 when correlation has been demonstrated.
- Bag-mask ventilation (BMV) is the recommended first line method to support ventilation.
  - Ensure a correct head position and mask size and a proper seal between mask and face.
  - Use an appropriately sized bag for age. To provide adequate TV, the inspiratory time should be sufficiently long (approx. 1 s). However, at all times, be careful to avoid hyperinflation.
  - Use a 2-person approach, especially if ventilation is difficult or when there is a risk of disease transmission. Consider airway adjuncts.
  - If competent, consider early placing a supraglottic airway (SGA) or a tracheal tube (TT) in cases where BMV does not improve oxygenation and/or ventilation or is anticipated to be prolonged.
- Tracheal intubation (TI) should only be performed by a competent provider, following a well-defined procedure, and having the necessary materials and drugs. The decision to intubate should always be balanced against the associated risk of the procedure.
  - The oral route for TI is preferable during emergencies.
  - External laryngeal manipulation should only be applied at the discretion of the provider performing the intubation.
  - Use cuffed tracheal tubes for PLS (except maybe in small infants). Monitor cuff inflation pressure and limit this according to manufacturer's recommendations (usually < 20 to 25 cmH2O).

- Use appropriate medication to facilitate intubation and provide subsequent analgosedation in all children unless they are in cardiorespiratory arrest.
- Monitor haemodynamics and SpO2 during intubation and be aware that bradycardia and desaturation are late signs of hypoxia.
- Avoid prolonged laryngoscopy and/or multiple attempts. Anticipate potential cardiorespiratory problems and plan an alternative airway management technique in case the trachea cannot be intubated.
- Competent providers should consider the (early) use of videolaryngoscopy, in cases where direct laryngoscopy is expected to be difficult.
- Once intubated, confirmation of proper TT position is mandatory. Evaluate clinically and by means of imaging. Use capnography in all intubated children for early detection of obstruction, mal- or displacement.

- Supraglottic airways – SGAs (such as I-gel, LMA) may be an alternative way to provide airway control and ventilation, although they do not totally protect the airway from aspiration. Easier to insert than a TT, an SGA should also only be inserted by a competent provider.
- Sudden rapid deterioration of a child being ventilated (via mask or TT) is a time-critical event that demands immediate action. Consider 'DOPES':
  - D stands for displacement (TT, mask)
  - for obstruction (TT, airway circuit, airway – head position)
  - P for pneumothorax
  - E for equipment (oxygen, tubing, connections, valves)
  - S for stomach (abdominal compartment)

Management of status asthmaticus

- Recognition of a severe asthma crisis is based upon clinical signs, brief history taking, as well as monitoring of SpO_2.
  - Lung function determination (PEF or PEV1) is of added value in children > 6 years old, if this can be easily measured without delaying treatment.
  - Arterial blood gas analysis is not routine but might be informative when the child does not respond to treatment or deteriorates. Continue oxygen therapy when taking the sample. Due to compensation, $PaCO_2$ might initially be normal or decreased. Hypercapnia is a sign of decompensation.
  - A chest X-ray is not routine but might be indicated if an alternative diagnosis or a complication is suspected.
- Timely, aggressive and protocolised treatment is needed in case of status asthmaticus:
  - Provide a comfortable environment and body position. Avoid sedative drugs, even if there is agitation.
  - Give supplemental oxygen titrated to achieve a SpO_2 of 94–98%. Give oxygen at high dose if SpO_2 cannot be measured but only until titration is possible.
  - Use short-acting beta-2 agonists (SABA) via an inhaler with spacer (e.g. salbutamol 2–10 puffs) or nebuliser (e.g. salbutamol 2.5–5 mg (0.15 mg/kg). Adjust doses to response and repeat as needed (up to continuously in the first hour). The effect of SABA begins within seconds and reaches a maximum at 30 min (half-life 2–4 h). Add short-acting anticholinergics (e.g. ipratropium bromide 0.25–0.5 mg) either nebulised or as an inhaler with spacer.
  - Give systemic corticosteroids within the first hour, either oral or intravenously (IV). Providers are advised to use the corticoid they are most familiar with (e.g. prednisolone 1–2 mg/kg, with a maximum of 60 mg/day).
  - Consider IV magnesium for severe and life-threatening asthma. Give a single dose of 50 mg/kg over 20 min (max 2 g). In children, isotonic magnesium might alternatively be used as nebulised solution (2.5 ml of 250 mmol/l; 150 mg).
  - Additional drugs can be considered by competent providers e.g. IV ketamine, IV aminophylline, etc. Providers should be aware that IV SABA carry a significant risk of electrolyte disorders, hyperlactatemia, and more importantly cardiovascular failure. If used, the child should be monitored carefully.
  - Antibiotics are not recommended unless there is evidence of bacterial infection.
  - There is no place for routine systemic or local adrenaline in asthma, but anaphylaxis should be excluded as an alternative diagnosis in all children with sudden onset of symptoms.
  - If available, consider NIV or HFNC in children with status asthmaticus needing oxygenation support beyond standard FiO_2 and/or not responding to initial treatment.
  - Severe exhaustion, deteriorating consciousness, poor air entry, worsening hypoxaemia and/or hypercapnia, and cardiopulmonary arrest are indications for tracheal intubation. Mechanical ventilation of a child with status asthmaticus is extremely challenging and expert help should be sought early on. Limit TV and respiratory rate and use a longer expiratory time.

Management of anaphylaxis

- Early diagnosis of anaphylaxis is crucial and will guide further treatment:
  - Acute onset of an illness (minutes to hours) with involvement of the skin, mucosal tissue, or both and at least one of the following:
    a. Respiratory compromise e.g. dyspnoea, wheeze-bronchospasm, stridor, reduced PEF, hypoxaemia
    b. Reduced blood pressure or associated symptoms of end-organ dysfunction e.g. collapse, syncope
    c. Severe gastrointestinal symptoms, especially after exposure to non-food allergens
- OR
  - Acute onset (minutes to several hours) of hypotension or bronchospasm or laryngeal involvement after exposure to a known or probable allergen, even in the absence of typical skin involvement.
- As soon as anaphylaxis is suspected, immediately administer intramuscular (IM) adrenaline (anterolateral mid-thigh, not subcutaneous). Provide further ABCDE care as needed: call for help, airway support, oxygen therapy, ventilatory support, venous access, repetitive fluid boluses and vasoactive drugs.
  - Early administration of IM adrenaline might also be considered for milder allergic symptoms in children with a history of anaphylaxis.
  - The dose for IM adrenaline is 0.01 mg/kg; this can be administered by syringe (1 mg/ml solution) but in most settings auto-injectable adrenaline will be the only form available (0.15 mg (<6 y) – 0.3 mg (6–12 y) – 0.5 mg (>12 y)).
  - If symptoms do not improve rapidly, give a second dose of IM adrenaline after 5–10 min.
  - In cases of refractory anaphylaxis competent physicians might consider the use of IV or intraosseous (IO) adrenaline. Be careful to avoid dosage errors.
- Prevent any further exposure to the triggering agent. In the case of a bee sting, remove the sting as quickly as possible.

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- Recognise cardiac arrest and start standard CPR when indicated. Rescuers only having access to IM adrenaline might consider giving this when cardiac arrest has just occurred.
- Consider early TI in case of respiratory compromise. Anticipate airway oedema. Airway management in case of anaphylaxis can be very complicated and early support by highly competent physicians is mandatory.
- In addition to IM adrenaline, consider the use of:
  - Inhaled SABA (and/or inhaled adrenaline) for bronchospasm.
  - IV or oral H1 and H2 antihistamines to alleviate subjective symptoms (especially cutaneous symptoms).
  - Glucocorticosteroids (e.g. methylprednisolone 1–2 mg/kg) only for children needing prolonged observation.
  - Specific treatments related to the context.
- After treatment, further observe for potential late or biphasic symptoms. Those children who responded well to one dose of IM adrenaline without any other risk factor can generally be discharged after 4–8 h. Prolonged observation (12–24 h) is advised for children with a history of biphasic or protracted anaphylaxis or asthma, those who needed more than one dose of IM adrenaline or had a delay between symptoms and first adrenaline dose of more than 60 min.
- Efforts should be made to identify the potential trigger. Without delaying treatment, take blood samples for mast cell tryptase upon arrival and ideally 1–2 h later. Refer patients to a dedicated healthcare professional for follow-up. Every child who had an anaphylactic reaction should have auto-injectable adrenaline prescribed and receive instructions how to use it (both the child, if feasible, and their caregivers).

Management of circulatory failure [C]

- Healthcare systems should implement context-specific protocols for the management of children with shock including strategies for early recognition and timely emergency treatment.
- The management of a child in circulatory failure needs to be tailored to the individual, considering aetiology, pathophysiology, age, context, comorbidities, and available resources. The transition from a compensated state to decompensation may be rapid and unpredictable. No single finding can reliably identify the severity of the circulatory failure and/or be used as a goal for treatment. Reassess frequently and at least after every intervention. Consider among others clinical signs, MAP, trends in lactate, urine output and if competent, ultrasound findings. Competent physicians might also measure advanced haemodynamic variables such as cardiac index, systemic vascular resistance, and central venous oxygen saturation (ScvO2), but this is not a priority in the first hour of care.
- The management of a child in circulatory failure, in accordance with the ABCDE approach, should always include proper management of airway, oxygenation and ventilation.
- Vascular Access:
  - Peripheral IV lines are the first choice for vascular access. Competent providers might use ultrasound to guide cannulation. In case of an emergency, limit the time for placement to 5 min (2 attempts) at most. Use rescue alternatives earlier when the chances of success are considered minimal.
  - For infants and children, the primary rescue alternative is intraosseous (IO) access. All paediatric advanced life support (ALS) providers should be competent in IO placement and have regular retraining in the different devices (and puncture sites) used in their setting. Provide proper analgesia – in every child unless comatose. Use a properly sized needle. Most standard pumps will not infuse via IO, so use either manual infusion or a high-pressure bag. Confirm proper placement and monitor for extravasation which can lead to compartment syndrome.
- Fluid therapy:
  - Give one or more early fluid bolus(es) of 10 ml/kg in children with recognised shock. Repeated fluid boluses – up to 40–60 ml/kg – might be needed in the first hour of treatment of (septic) shock.
  - Reassess after each bolus and avoid repeated boluses in children who cease to show signs of decreased perfusion or show signs of fluid overload or cardiac failure. Combine clinical signs with biochemical values and if possible, imaging such as cardiac and lung ultrasound to assess the need for additional boluses. In case of repeated fluid boluses, consider vasoactive drugs and respiratory support early on. In settings where intensive care is not available, it seems prudent to be even more restrictive.
  - Use balanced crystalloids as first choice of fluid bolus, if available. If not, normal saline is an acceptable alternative. Consider albumin as second-line fluid for children with sepsis, especially in the case of malaria or dengue fever. If not for haemorrhagic shock, blood products are only needed when blood values fall below an acceptable minimum value.
  - Give rapid fluid boluses in children with hypovolemic non-haemorrhagic shock. Otherwise, fluid resuscitation of severely dehydrated children can generally be done more gradually (up to e.g. 100 ml/kg over 8 h).
  - In cases of haemorrhagic shock, keep crystalloid boluses to a minimum (max. 20 ml/kg). Consider early blood products – or if available, full blood- in children with severe trauma and circulatory failure, using a strategy that focuses on improving coagulation (using at least as much plasma as RBC and considering platelets, fibrinogen, other coagulation factors). Avoid fluid overload but try to provide adequate tissue perfusion awaiting definitive damage control and/or spontaneous haemostasis. Permissive hypotension (MAP at 5th percentile for age) can only be considered in children when there is no risk of associated brain injury.
  - Give tranexamic acid (TxA) in all children requiring transfusion after severe trauma – as soon as possible, within the first 3 h after injury- and/or significant haemorrhage. Consider TxA in children with isolated moderate TBI (GCS 9–13) without pupillary abnormalities. Use a loading dose at 15–20 mg/kg (max. 1 g), followed by an infusion of 2 mg/kg/h for at least 8 h or until the bleeding stops (max. 1 g).
- Vasoactive/Inotropic drugs:
  - Start vasoactive drugs early, as a continuous infusion (diluted as per local protocol) via either a central or peripheral line, in children with circulatory failure when there is no improvement of the clinical state after multiple fluid boluses. Attention should be given to proper dilution, dosing and infusion management. Preferably use a dedicated line with proper flow, avoiding inadvertent boluses or sudden dose changes. Titrate these drugs based on a desired target MAP, which may differ with pathology, age and patient response; in an ICU setting other haemodynamic variables may also be taken into account.

- ○ Use either noradrenaline or adrenaline as first-line inoconstrictors and dobutamine or milrinone as first-line inodilators. Dopamine should be considered only in settings where neither adrenaline nor noradrenaline are available. All paediatric ALS providers should be competent in the use of these drugs during the first hour of stabilisation of a child in circulatory failure.
- ○ Also use vasoactive drugs in cases of hypovolemic shock, when fluid-refractory −especially when there is loss of sympathetic drive such as during anaesthesia−, as well as for children with hypovolemic shock and concomitant TBI. A sufficiently high MAP is needed to attain an adequate cerebral perfusion pressure (e.g. MAP above 50th percentile). Evaluate and, if necessary, support cardiac function.

- Additional therapies in septic shock:
  - ○ Consider a first dose of stress-dose hydrocortisone (1−2 mg/kg) in children with septic shock, unresponsive to fluids and vasoactive support, regardless of any biochemical or other parameters.
  - ○ Give stress-dose hydrocortisone in children with septic shock who also have acute or chronic corticosteroid exposure, hypothalamic-pituitary-adrenal axis disorders, congenital adrenal hyperplasia, or other corticosteroid- related endocrinopathies, or have recently been treated with ketoconazole or etomidate.
  - ○ Start broad-spectrum antibiotics as soon as possible after initial ABCD management. Preferably, this is within the first hour of treatment. Obtain blood cultures (or blood samples for PCR) before starting, if this can be done without delaying therapy.
- Obstructive shock in children:
  - ○ Tension pneumothorax requires immediate treatment by either emergency thoracostomy or needle thoracocentesis. Use ultrasound to confirm the diagnosis if this does not delay treatment. For both techniques, use the 4th or 5th intercostal space (ICS) slightly anterior to the midaxillary line as the primary site of entry. In children, the 2nd ICS midclavicular remains an acceptable alternative. Convert to standard chest tube drainage as soon as practically feasible.
  - ○ Systems that do not implement immediate thoracostomy should at least consider thoracostomy as a rescue option in paediatric severe trauma and train their providers accordingly.
  - ○ If available, use ultrasound to diagnose pericardial tamponade. Tamponade leading to obstructive shock demands immediate decompression by pericardiocentesis, thoracotomy or (re) sternotomy according to circumstances and available expertise. Depending on their context, systems should have protocols in place for this.
- Unstable primary bradycardia:
  - ○ Consider atropine (20 mcg/kg; max. 0.5 mg per dose) only in bradycardia caused by increased vagal tone.
  - ○ Consider emergency transthoracic pacing in selected cases with circulatory failure due to bradycardia caused by complete heart block or abnormal function of the sinus node. Early expert help is mandatory.
- Unstable primary tachycardia:
  - ○ In children with decompensated circulatory failure due to either supraventricular (SVT) or ventricular tachycardia (VT), the first choice for treatment is immediate synchronised electrical cardioversion at a starting energy of 1 J/kg body weight. Double the energy for each subsequent attempt up to a maximum of 4 J/kg. If possible, this should be guided by expert help. For children who are not yet unconscious, use adequate analgosedation according to local protocol. Check for signs of life after each attempt.
  - ○ In children with a presumed SVT who are not yet decompensated, providers can try vagal manoeuvres (e.g. ice application, modified Valsalva techniques). If this has no immediate effect, proceed with IV adenosine. Give a rapid bolus of 0.1−0.2 mg/kg (max 6 mg) with immediate saline flush via a large vein; ensure a rhythm strip is running for later expert evaluation. Especially in younger children, higher initial doses are preferable. In case of persistent SVT, repeat adenosine after at least 1 min at a higher dose (0.3 mg/kg, max 12−18 mg). Be cautious with adenosine in children with known sinus node disease, pre-excited atrial arrhythmias, heart transplant or severe asthma. In such cases, or when there is no prolonged effect of adenosine, competent providers (with expert consultation) might give alternative medications.
  - ○ Wide QRS tachycardias can be either VT or SVT with bundle branch block aberration, or antegrade conduction through an additional pathway. In case the mechanism of the arrhythmia is not fully understood, wide QRS arrhythmia should be treated as VT. In a child who is haemodynamically stable, the response to vagal manoeuvres may provide insight into the mechanism responsible for the arrhythmia and competent providers (with expert help) can subsequently try pharmacological treatment. Even in stable patients, electrical cardioversion should always be considered. In case of Torsade de pointes VT, IV magnesium 50 mg/kg is indicated.

Management of 'neurological' and other medical emergencies [D] [E]

Recognise and treat neurological emergencies quickly, because prognosis is worsened by secondary injury (due to e.g. hypoxia, hypotension) and treatment delays. In accordance with the ABCDE approach, such treatment includes proper management of airway, oxygenation and ventilation, and circulation.

Status epilepticus

- Identify and manage underlying diagnoses and precipitant causes including hypoglycaemia, electrolyte disorders, intoxications, brain infections and neurological diseases, as well as systemic complications such as airway obstruction, hypoxaemia or shock.
- If convulsions persist for more than 5 min, give a first dose of a benzodiazepine. Immediate treatment should be considered in specific situations. Which benzodiazepine via which route to give will depend on the availability, context, social preference, and expertise of the providers. Non-IV benzodiazepines should be used if an IV line is not (yet) available. Adequate dosing is essential, we suggest:
  - ○ IM midazolam 0.2 mg/kg (max 10 mg) or prefilled syringes: 5 mg for 13−40 kg, 10 mg > 40 kg); intranasal/buccal 0.3 mg/kg; IV 0.15 mg/kg (max 7.5 mg)
  - ○ IV lorazepam 0.1 mg/kg (max 4 mg)
  - ○ IV diazepam 0.2−0.25 mg/kg (max 10 mg)/rectal 0.5 mg/kg (max 20 mg)
- If convulsions persist after another 5 min, administer a second dose of benzodiazepine and prepare a long-acting second line drug for administration. Seek expert help.
- Not later than 20 min after convulsions started, give second line anti-epileptic drugs. The choice of drug will again depend on

context, availability, and expertise of the provider. Adequate dosing is again essential:
- Levetiracetam 40–60 mg/kg IV (recent papers suggest the higher dose; max. 4.5 g, over 15′)
- Phenytoin 20 mg/kg IV (max. 1.5 g, over 20 min; or alternatively phosphenytoin)
- Valproic acid 40 mg/kg IV (max 3 g; over 15 min; avoid in cases of presumed hepatic failure or metabolic diseases – which can never be ruled out in infants and younger children-, as well as in pregnant teenagers).
- Phenobarbital (20 mg/kg over 20 min) IV is a reasonable second-line alternative if none of the three recommended therapies are available.

- If convulsions continue, consider an additional second-line drug after the first second-line drug has been given.
- Not later than 40 min after convulsions started, consider anaesthetic doses (given by a competent provider) of either midazolam, ketamine, pentobarbital/thiopental, or propofol; preferably under continuous EEG monitoring. Prepare for adequate support of oxygenation, ventilation and perfusion as needed.
- Non-convulsive status epilepticus can continue after clinical convulsions cease; all children who do not completely regain consciousness need EEG monitoring and appropriate treatment.

Hypoglycaemia

- Recognise hypoglycaemia using context, clinical signs, and measurement (50–70 mg/dl; 2.8–3.9 mmol/L), and promptly treat this. Also identify and treat any underlying cause. Specific dosage of IV glucose maintenance might be indicated in specific metabolic diseases.
- Mild asymptomatic hypoglycaemia may be treated with standard glucose administration, either by maintenance infusion glucose (6–8 mg/kg/min) or by oral rapid acting glucose (0.3 g/kg tablets or equivalent), followed by additional carbohydrate intake to prevent recurrence.
- Severe paediatric hypoglycaemia (<50 mg/dl (2.8 mmol/L) with neuroglycopenic symptoms) demands:
  - IV glucose 0.3 g/kg bolus; preferably as 10% (100 mg/ml; 3 ml/kg) or 20%-solution (200 mg/ml; 1.5 ml/kg)
  - When IV glucose is not available, providers may administer glucagon as temporary rescue, either IM or SC (0.03 mg/kg or 1 mg >25 kg; 0.5 mg <25 kg) or intranasally (3 mg; 4-16y).
  - Retest blood glucose 10 min after treatment and repeat treatment if the response is inadequate. Reasonable targets are an increase of at least 50 mg/dl (2.8 mmol/L) and/or a target glycaemia of 100 mg/dL (5.6 mmol/L).
  - Start a glucose maintenance infusion (6–8 mg/kg/min) to reverse catabolism and maintain adequate glycaemia.

Hypokalaemia

- For severe hypokalaemia (<2.5 mmol/L) in a pre-arrest state, give IV boluses of 1 mmol/kg (max 30 mmol) over at least 20 min to a monitored child and repeat until the serum potassium is above 2.5 mmol/L avoiding inadvertent hyperkalaemia. Also give IV magnesium 30–50 mg/kg.
- In all other cases, enteral potassium is preferred for those who tolerate enteral supplementation. The eventual dose should depend on the clinical presentation, the value measured and the expected degree of depletion.

Hyperkalaemia

- To evaluate the severity of hyperkalaemia, consider the potassium value in the context of the underlying cause and contributing factors, and the presence of potassium-related ECG changes. Eliminate or treat underlying causes and contributing factors as soon as possible.
- Tailor emergency treatment to the individual child. Consider early expert help. In children with acute symptomatic life-threatening hyperkalaemia give:
  - Calcium (e.g. calcium gluconate 10% 0.5 ml/kg max 20 ml) for membrane stabilisation. This works within minutes and the effect lasts 30–60 min.
  - Fast-acting insulin with glucose to redistribute potassium, which is effective after about 15 min, peaks at 30–60 min and lasts 4–6 h (e.g. 0.1 U/kg insulin in a 1 IU insulin in 25 ml glucose 20% solution; there is no need for initial glucose when the initial glycaemia is > 250 mg/dl (13.9 mmol/L)). Repeated dosing might be necessary. To avoid hypoglycaemia, once hyperkalaemia is treated, continue with a glucose maintenance infusion without insulin. Monitor blood glucose levels.
  - Nebulised beta-agonists at high dose (e.g. 5 times the bronchodilation dose), however be aware that the maximal effect is reached only after 90 min.
  - Sodium bicarbonate 1 mmol/kg IV (repeat as necessary) in case of a metabolic acidosis (pH < 7.2) and/or in cardiac arrest. The effect of sodium bicarbonate is slow (hours).
- Continue potassium redistribution measures until potassium removal treatments become effective. Potassium removal can be done by potassium binding agents, furosemide (in well-hydrated children with preserved kidney function) and/or dialysis.

Hyperthermia

- In cases of heat stroke (i.e. a central body temperature ≥40–40.5 °C with central nervous system (CNS) dysfunction):
  - Monitor central body temperature as soon as possible (rectal, oesophageal, bladder, intravascular).
  - Prehospital treatment consists of full ABCDE management and rapid aggressive cooling. Remove the child from the heat source. Undress and fan with cold air and mist. Apply ice packs. Provide early evaporative external cooling. Consider cold-water immersion for adolescents and young adults.
  - Further cooling in hospital can be done by placing the child on a cooling blanket; applying ice packs to the neck, axilla and groin or alternatively on the smooth skin surfaces of the cheeks, palms, and soles; and infusion of IV crystalloids at room temperature. Stop cooling measures once the core temperature reaches 38 °C. Benzodiazepines are suggested to avoid trembling, shivering or seizures during cooling measures. Classic antipyretic medications are ineffective.
  - All children with heat stroke should be admitted to a (paediatric) intensive care unit to maintain adequate monitoring and to treat associated organ dysfunction.

Paediatric basic life support

The sequence of actions in paediatric BLS (PBLS) support (Fig. 16) will depend upon the level of training of the rescuer attending: those fully competent in PBLS (preferred algorithm), those trained only in ‘adult’ BLS and those untrained (dispatcher-assisted lay rescuers).

Sequence of actions in PBLS

- Ensure safety of rescuer and child. Check for responsiveness to verbal and tactile stimulation. Ask bystanders to help.
- If the child does not respond, open the airway, and assess breathing for no longer than 10 s.
  - If you have difficulty opening the airway with head tilt – chin lift or specifically in cases of trauma, use a jaw thrust. If needed, add head tilt a small amount at a time until the airway is open.
  - In the first few minutes after a cardiac arrest a child may be taking slow infrequent gasps. If you have any doubt whether breathing is normal, act as if it is not normal.
  - Look for respiratory effort, listen and feel for movement of air from the nose and/or mouth. If there is effort but no air movement, the airway is not open.
  - In cases where there is more than one rescuer, a second rescuer should call the EMS immediately upon recognition of unconsciousness, preferably using the speaker function of a mobile phone.
- In the unconscious child, if breathing is abnormal: give five initial rescue breaths.
  - For infants, ensure a neutral position of the head. In older children, more extension of the head will be needed (head tilt).
  - Blow steadily into the child's mouth (or infant's mouth and nose) for about 1 s, sufficient to make the chest visibly rise.
  - If you have difficulty achieving an effective breath, the airway may be obstructed (see below): remove any visible obstruction. Do not perform a blind finger sweep. Reposition the head or adjust airway opening method. Make up to five attempts to achieve effective breaths, if still unsuccessful, move on to chest compressions.
  - Competent providers should use BMV with oxygen, when available, instead of expired air ventilation. In larger children when BMV is not available, competent providers can also use a pocket mask for rescue breaths.
  - If there is only one rescuer, with a mobile phone, he or she should call help first (and activate the speaker function) immediately after the initial rescue breaths. Proceed to the next step while waiting for an answer. If no phone is readily available perform 1 min of CPR before leaving the child.
  - In cases where PBLS providers are unable or unwilling to start with ventilations, they should proceed with compressions and add into the sequence ventilations as soon as these can be performed.
- Immediately proceed with 15 chest compressions, unless there are clear signs of circulation (such as movement, coughing). Rather than looking at each factor independently, focus on consistent good quality compressions as defined by:
  - Rate: 100–120 min−1 for both infants and children.
  - Depth: depress the lower half of the sternum by at least one third of the anterior–posterior dimension of the chest. Compressions should never be deeper than the adult 6 cm limit (approx. an adult thumb's length).
  - Recoil: Avoid leaning. Release all pressure between compressions and allow for complete chest recoil.

When possible, perform compressions on a firm surface. Move the child only if this results in markedly better CPR conditions (surface, accessibility). Remove clothes only if they severely hinder chest compressions.

Preferably use a two-thumb encircling technique for chest compression in infants – be careful to avoid incomplete recoil. Single rescuers might alternatively use a two-finger technique.

In children older than 1 year, depending on size and hand span, use either a one-hand or two-hand technique. In case the one-hand technique is used, the other hand can be positioned to maintain an open airway throughout (or to stabilise the compression arm at the elbow).

- After 15 compressions, 2 rescue breaths should follow and then alternating (15:2 duty cycle). Do not interrupt CPR at any moment unless there are clear signs of circulation (movement, coughing) or when exhausted. Two or more rescuers should change the rescuer performing chest compressions frequently and the individual rescuer should switch hands (the hand compressing, the hand on top) or technique (one to 2-handed) to avoid fatigue.
- In case there are clear signs of life, but the child remains unconscious not breathing normally, continue to support ventilation at a rate appropriate for age.

Rescuers only trained in adult BLS

BLS providers who are untrained in PBLS, should follow the adult CPR algorithm with ventilations, as they were trained, adapting the techniques to the size of the child. If trained, they should consider giving 5 initial rescue breaths before proceeding with compressions.

Untrained lay rescuers

- Cardiac arrest is determined to have occurred based on the combination of *unconsciousness and abnormal breathing*. As the latter is often difficult to identify or when there are concerns about safety (e.g. risk of viral transmission), rather than look-listen-feel, bystanders might also be guided by specific word descriptors or by feeling for respiratory movement.
- Bystander CPR should be started in all cases when feasible. The EMS dispatcher has a crucial role in assisting lay untrained bystanders to recognise CA and provide CPR. When bystander CPR is already in progress at the time of the call, dispatchers should probably only provide instructions when asked for or when issues with knowledge or skills are identified.
- The steps of the algorithm for paediatric dispatcher-assisted CPR are very similar to the PBLS algorithm. To decrease the number of switches, a 30:2 duty cycle might be preferable. If bystanders cannot provide rescue breaths, they should proceed with chest compressions only.

Use of an Automated External Defibrillator (AED)

- In children with a CA, a lone rescuer should immediately start CPR as described above. In cases where the likelihood of a primary shockable rhythm is very high such as in sudden witnessed collapse, if easily accessible, he or she can rapidly collect and apply an AED (at the time of calling EMS). In case there is more than one rescuer, a second rescuer will immediately call for help and then collect and apply an AED (if feasible).
- Trained providers should limit the no-flow time when using an AED by restarting CPR immediately after the shock delivery or no shock decision; pads should be applied with minimal or no interruption in CPR.
- If possible, use an AED with a paediatric attenuator in infants and children below 8 years. If such is not available, use a standard AED for all ages.

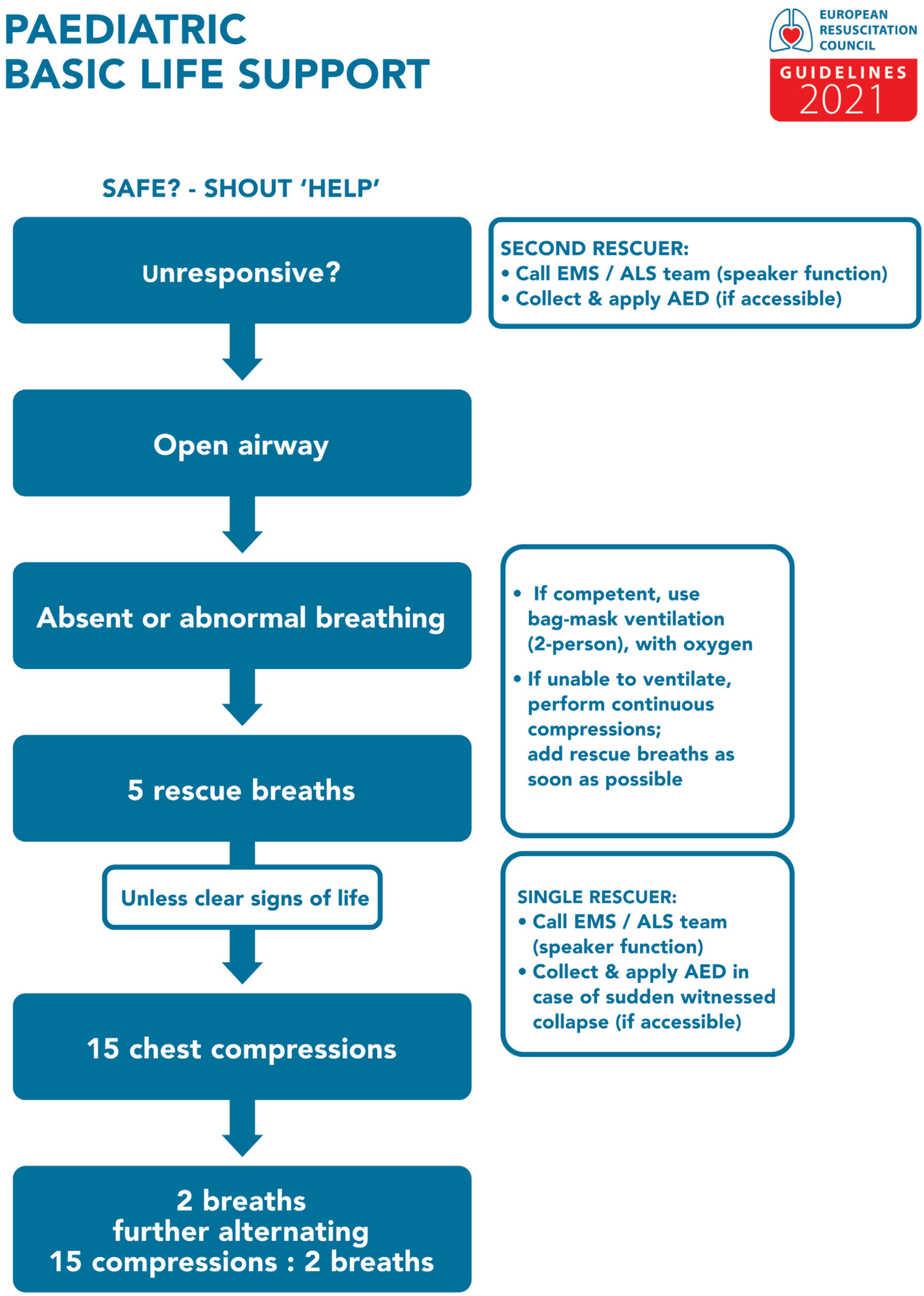

Fig. 16 – Paediatric basic life support algorithm.

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PBLS in case of traumatic cardiac arrest (TCA)

- Perform bystander CPR when confronted with a child in CA after trauma, provided it is safe to do so. Try to minimise spinal movement as far as possible during CPR without hampering the process of resuscitation, which clearly has priority.
- Do not routinely apply an AED at the scene of paediatric TCA unless there is a high likelihood of shockable underlying rhythm such as after electrocution.
- Apply direct pressure to stop massive external haemorrhage if possible, using haemostatic dressings. Use a tourniquet (preferably manufactured but otherwise improvised) in case of an uncontrollable, life-threatening external bleeding.

Recovery position

- Unconscious children who are not in CA and clearly have normal breathing, can have their airway kept open by either continued head tilt – chin lift or jaw thrust or, especially when there is a perceived risk of vomiting, by positioning the unconscious child in a recovery position.
- Once in recovery position, reassess breathing *every minute* to recognise CA as soon as it occurs (lay rescuers might need dispatcher guidance to do so).
- Avoid any pressure on the child's chest that may impair breathing and regularly change side to avoid pressure points (i.e. every 30 min).
- In unconscious trauma victims, open the airway using a jaw thrust, taking care to avoid spinal rotation.

Paediatric Foreign Body Airway Obstruction [FBAO]

- Suspect FBAO – if unwitnessed – when the onset of respiratory symptoms (coughing, gagging, stridor, distress) is very sudden and there are no other signs of illness; a history of eating or playing with small items immediately before the onset of symptoms might further alert the rescuer.
- As long as the child is coughing effectively (fully responsive, loud cough, taking a breath before coughing, still crying, or speaking), no manoeuvre is necessary. Encourage the child to cough and continue monitoring the child's condition.
- If the child's coughing is (becoming) ineffective (decreasing consciousness, quiet cough, inability to breathe or vocalise, cyanosis), ask for bystander help and determine the child's conscious level. A second rescuer should call EMS, preferably by mobile phone (speaker function). A single trained rescuer should first proceed with rescue manoeuvres (unless able to call simultaneously with the speaker function activated).
- If the child is still conscious but has ineffective coughing, give back blows. If back blows do not relieve the FBAO, give chest thrusts to infants or abdominal thrusts to children. If the foreign body has not been expelled and the victim is still conscious, continue the sequence of back blows and chest (for infant) or abdominal (for children) thrusts. Do not leave the child.
- The aim is to relieve the obstruction with each thrust rather than to give many of them.
- If the object is expelled successfully, assess the child's clinical condition. It is possible that part of the object may remain in the respiratory tract and cause complications. If there is any doubt or if the victim was treated with abdominal thrusts, urgent medical follow up is mandatory.
- If the child with FBAO is, or becomes, unconscious, continue according to the paediatric BLS algorithm. Competent providers should consider the use of Magill forceps to remove a foreign body.

Paediatric advanced life support

Sequence of actions in PALS

Although the sequence of actions is presented stepwise (Fig. 17), ALS is a team activity, and several interventions will be done in parallel. ALS teams should not only train in knowledge and skills but also in teamwork and the 'choreography' of ALS interventions.

- *Commence and/or continue with paediatric BLS*. Recognition of CA can be done on clinical grounds or based on monitored vital signs (ECG, loss of SpO_2 and/or $ETCO_2$, loss of blood pressure, etc.). Importantly, also start CPR in children who become bradycardic with signs of very low perfusion despite adequate respiratory support.
- If not already in place, apply cardiac monitoring as soon as possible using ECG-electrodes or self-adhesive defibrillator pads (or defibrillation paddles). *Differentiate between shockable and non-shockable cardiac rhythms*.
  - Non-shockable rhythms are pulseless electrical activity (PEA), bradycardia and asystole. If bradycardia (<60 per minute) is the result of hypoxia or ischaemia, CPR is needed even if there is still a detectable pulse. Therefore, providers should rather assess signs of life and not lose time by checking for a pulse. In the absence of signs of life, continue to provide high-quality CPR. Obtain vascular access and give adrenaline IV (10 mcg/kg, max 1 mg) as soon as possible. Flush afterwards to facilitate drug delivery. Repeat adrenaline every 3–5 min. In cases where it is likely to be difficult to obtain IV access, immediately go for IO access.
  - Shockable rhythms are pulseless ventricular tachycardia (pVT) and ventricular fibrillation (VF). As soon identified, defibrillation should immediately be attempted (regardless of the ECG amplitude). If in doubt, consider the rhythm to be shockable.
  - If using self-adhesive pads, continue chest compressions while the defibrillator is charging. Once charged, pause chest compressions, and ensure all rescuers are clear of the child. Minimise the delay between stopping chest compressions and delivery of the shock (<5 s). Give one shock (4 J/kg) and immediately resume CPR. Reassess the cardiac rhythm every 2 min (after the last shock) and give another shock (4 J/kg) if a shockable rhythm persists. Immediately after the third shock, give adrenaline (10 mcg/kg, max 1 mg) and amiodarone (5 mg/kg, max 300 mg) IV/IO. Flush after each drug. Lidocaine IV (1 mg/kg) might be used as an alternative to amiodarone by providers competent in its use. Give a second dose of adrenaline (10mcg/kg, max 1 mg) and amiodarone (5 mg/kg, max 150 mg) after the 5th shock if the child still has a shockable rhythm. Once given, adrenaline should be repeated every 3–5 min.
  - Change the person doing compressions at least every 2 min. Watch for fatigue and/or suboptimal compressions and switch rescuers earlier if necessary.
  - CPR should be continued unless:
    - An organised potentially perfusing rhythm is recognised (upon rhythm check) and accompanied by signs of return of spontaneous circulation (ROSC), identified clinically (eye opening, movement, normal breathing) and/or by monitoring (etCO2, SpO2, blood pressure, ultrasound)

- There are criteria for withdrawing resuscitation (see the ERC guideline chapter on ethics).

Defibrillation during paediatric ALS

Manual defibrillation is the recommended method for ALS, but if this is not immediately available an AED can be used as alternative.

- Use 4 J/kg as the standard energy dose for shocks. It seems reasonable not to use doses above those suggested for adults (120−200 J, depending on the type of defibrillator). Consider escalating doses −stepwise increasing up to 8 J/Kg and max. 360 J − for refractory VF/pVT (i.e. more than 5 shocks needed).
- Defibrillation via self-adhesive pads has become the standard. If unavailable, the use of paddles (with preformed gel pads) is still considered an acceptable alternative yet demands specific alterations to the choreography of defibrillation. Charging should then be done on the chest directly, already pausing compressions at that stage. *Good planning before each action* will minimise hands-off time.

Pads should be positioned either in the antero-lateral (AL) or the antero-posterior (AP) position. Avoid contact between pads as this will create charge arcing. In the AL position, one pad is placed below the right clavicle and the other in the left axilla. In the AP position the anterior pad is placed mid-chest immediately left to the sternum and the posterior in the middle of the back between the scapulae.

Oxygenation and ventilation during paediatric ALS

- Oxygenate and ventilate with BMV, using a high concentration of inspired oxygen (100%). Do not titrate FiO2 during CPR.
  - Consider insertion of an advanced airway (TT, SGA) in cases where CPR during transport or prolonged resuscitation is anticipated and a competent provider is present. Where it is impossible to ventilate by BMV, consider the early use of an advanced airway or rescue technique. Use etCO2 monitoring when an advanced airway is in place.
  - Always avoid hyperventilation (due to excessive rate and/or TV). However, also take care to ensure that lung inflation is adequate during chest compressions. TV can be estimated by looking at chest expansion.
- In cases of CPR with positive pressure ventilation via a TT, ventilations can be asynchronous and chest compressions continuous (only pausing every 2 min for rhythm check). In this case, ventilations should approximate to the lower limit of normal rate for age e.g. breaths/min: 25 (infants), 20 (>1 y), 15 (>8 y), 10 (>12 y).
- For children already on a mechanical ventilator, either disconnect the ventilator and ventilate by means of a self-inflating bag or continue to ventilate with the mechanical ventilator. In the latter case, ensure that the ventilator is in a volume-controlled mode, that triggers and limits are disabled, and ventilation rate, TV and FiO_2 are appropriate for CPR. There is no evidence to support any specific level of PEEP during CPR. Ventilator dysfunction can itself be a cause of cardiac arrest.
- Once there is sustained ROSC, titrate FiO_2 to an SpO_2 of 94 −98%. Competent providers should insert an advanced airway, if not already present, in children who do not regain consciousness or for other clinical indications.

Measurable factors during ALS

- Capnography is mandatory for the monitoring of TT position. It however does not permit identification of selective bronchial intubation. When in place during CPR, it can help to rapidly detect ROSC. $ETCO_2$ values should not be used as quality indicator or target during paediatric ALS, nor as an indication for or against continuing CPR.
- Invasive blood pressure should only be considered as a target during paediatric ALS by competent providers for children with in-hospital CA [IHCA] where an arterial line is already in place. Blood pressure values should not be used to predict outcome.
- Point of care ultrasound can be used by competent providers to identify reversible causes of CA. Its use should not increase hands-off time or impact quality of CPR. Image acquisition is best done during pauses for rhythm check and/or for ventilations; the team should plan and anticipate (choreography) to make the most of the available seconds for imaging.
- Point of care serum values (of e.g. potassium, lactate, glucose, . . .) can be used to identify reversible causes of cardiac arrest but should not be used for prognostication. Providers should be aware that the measured values may differ significantly, depending on the measurement technique and sampling site.

Special circumstances − reversible causes

- The early identification and proper treatment of any reversible cause during CPR is a priority for all ALS providers. Use the mnemonic “4H4T” to remember what to actively look for: Hypoxia; Hypovolemia; Hypo- or hyperkalaemia/-calcaemia/-magnesemia & hypoglycaemia; Hypo- or Hyperthermia; Tension pneumothorax; Tamponade; Thrombosis (Cardiac−Pulmonary); Toxic Agents.
- Unless otherwise specified, the specific treatment for each of these causes is the same in CA as in acute life-threatening disease (see above and the dedicated chapter on special circumstances within these guidelines).
- Providers should consider (as per protocol and if possible, with expert help) specific treatments for intoxications with high-risk medications (e.g. beta-blockers, tricyclic antidepressants, calcium channel blockers, digitalis, or insulin). For certain life-threatening intoxications extracorporeal treatments should be considered early on and these patients should be transferred to a centre that can perform these in children, ideally before cardiovascular or neurological failure occurs (based upon the context of the intoxication rather than the actual symptoms).
- Specific conditions such as cardiac surgery, neurosurgery, trauma, drowning, sepsis, pulmonary hypertension also demand a specific approach. Importantly, the more widespread use of extracorporeal life support/CPR [ECLS/eCPR] has thoroughly redefined the whole concept of ‘reversibility’.
  - Institutions performing cardiothoracic surgery in children should establish institution-specific algorithms for cardiac arrest after cardiothoracic surgery.
  - Standard ALS may be ineffective for children with CA and pulmonary hypertension (PHT). Actively search for reversible causes of increased pulmonary vascular resistance such as cessation of medication, hypercarbia, hypoxia, arrhythmias, cardiac tamponade, or drug toxicity. Consider specific treatments like pulmonary vasodilators.

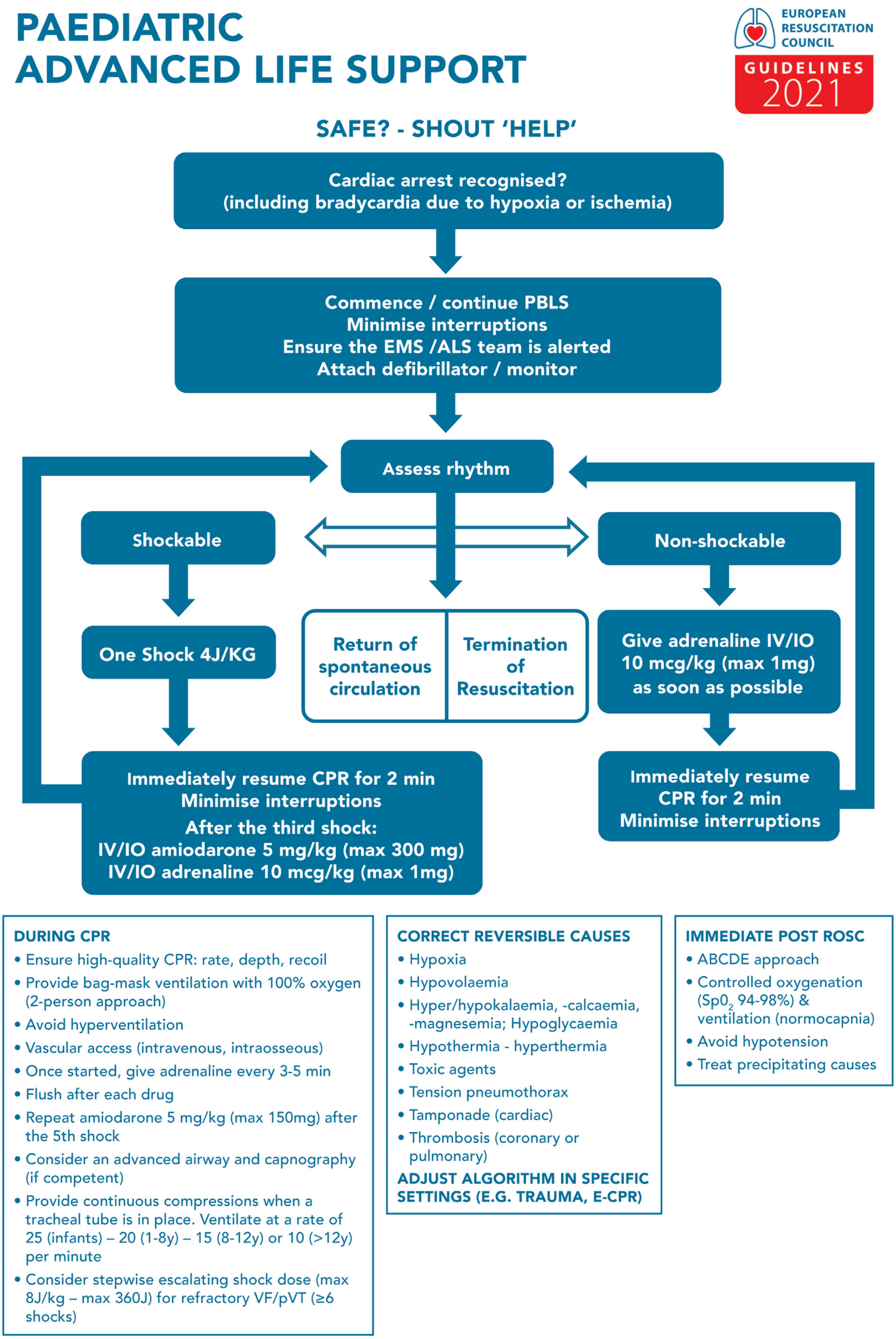

Fig. 17 – Paediatric advanced life support algorithm.

Traumatic Cardiac Arrest TCA

- In case of TCA, start standard CPR while searching for and treating any of the reversible causes of paediatric TCA:
  - airway opening and ventilation with oxygen
  - external haemorrhage control including the use of tourniquets in exsanguinating injury to the extremities
  - bilateral finger or tube thoracostomy (or needle thoracocentesis)
  - IO/IV access and fluid resuscitation (if possible, with full blood or blood products), as well as the use of the pelvic binder in blunt trauma.
- Chest compressions are performed simultaneously with these interventions depending on the available personnel and procedures. Based on the mechanism of injury, correction of reversible causes might precede adrenaline administration.
- Consider emergency department (ED) thoracotomy in paediatric TCA patients with penetrating trauma with or without signs of life on ED arrival. In some EMS systems, highly competent professionals might also consider pre-hospital thoracotomy for these patients (or for children with selected blunt injury).

Hypothermic arrest

- Adapt standard paediatric ALS actions for hypothermia (see also the chapter on special circumstances). Start standard CPR for all victims in CA. If continuous CPR is not possible and the child is deeply hypothermic (<28 °C), consider delayed or intermittent CPR.
- Any child who is considered to have any chance of a favourable outcome should ideally be transported as soon as possible to a (paediatric) reference centre with ECLS or cardiopulmonary bypass capacity.

Extracorporeal life support

- E-CPR should be considered early for children with ED or IHCA and a (presumed) reversible cause when conventional ALS does not promptly lead to ROSC, in a healthcare context where expertise, resources and sustainable systems are available to rapidly initiate ECLS.
- For specific subgroups of children with decompensated cardiorespiratory failure (e.g. severe refractory septic shock or cardiomyopathy or myocarditis and refractory low cardiac output), pre-arrest use of ECLS can be beneficial to provide end-organ support and prevent cardiac arrest. IHCA shortly prior to or during cannulation should not preclude ECLS initiation.
- Competent providers might also decide to perform E-CPR for OHCA in cases of deep hypothermic arrest or when cannulation can be done prehospitally by a highly trained team, within a dedicated healthcare system.

Post-resuscitation care

The eventual outcome of children following ROSC depends on many factors, some of which may be amenable to treatment. Secondary injury to vital organs might be caused by ongoing cardiovascular failure from the precipitating pathology, post-ROSC myocardial dysfunction, reperfusion injury, or ongoing hypoxaemia.

- Haemodynamic: Avoid post-ROSC hypotension (i.e. MAP < 5th percentile for age). Aim for a blood pressure at or above the p50, taking into account the clinical signs, serum lactate and/or measures of cardiac output. Use the minimum necessary doses of parenteral fluids and vasoactive drugs to achieve this. Monitor all interventions and adjust continuously to the child's physiological responses.
- Ventilation: Provide a normal ventilatory rate and volume for the child's age, to achieve a normal $PaCO_2$. Try to avoid both hypocarbia and hypercarbia. In a few children the usual values for $PaCO_2$ and PaO_2 may deviate from the population normal values for age (e.g. in children with chronic lung disease or congenital heart conditions); aim to restore values to that child's normal levels. Do not use $etCO_2$ as a surrogate for PaCO2 when aiming for normocapnia as part of neuroprotective care unless there is a proven correlation.
- Oxygenation: Titrate FiO_2 to achieve normoxaemia or, if arterial blood gas is not available, maintain SpO_2 in the range of 94−98%. Maintain high FiO_2 in presumed carbon monoxide poisoning or severe anaemia.
- Use targeted temperature management TTM: Avoid fever (≤37.5°), maintain a specific set temperature, by means of, for instance, external cooling. Lower target temperatures (e.g. 34 °C) demand appropriate systems of paediatric critical care and should only be used in settings with the necessary expertise. Alternatively, the attending team can aim for higher target temperature, e.g. 36 °C.
- Glucose control: monitor blood glucose and avoid both hypo- and hyperglycaemia. Be aware that tight glucose control may be harmful, due to a risk of inadvertent hypoglycaemia.

Although several factors are associated with outcome after cardiopulmonary arrest, no single factor can be used in isolation for prognostication. Providers should use multiple variables in the pre-, intra-, and post-CA phases in an integrated way, including biological markers and neuroimaging.

Ethics

These European Resuscitation Council Ethics guidelines provide evidence-based recommendations for the ethical, routine practice of resuscitation and end-of-life care of adults and children. The guideline primarily focus on major ethical practice interventions (i.e. advance directives, advance care planning, and shared decision making), decision making regarding resuscitation, education, and research. These areas are tightly related to the application of the principles of bioethics in the practice of resuscitation and end-of-life care.

Key messages from this section are presented in Fig. 18.

Major interventions aimed at safeguarding autonomy

Patient preferences and treatment decisions

Clinicians should:

- Use advance care planning that incorporates shared decision making to improve consistency between patient wishes and treatment
- Offer advance care planning to all patients at increased risk of cardiac arrest or poor outcome in the event of cardiac arrest.
- Support advance care planning in all cases where it is requested by the patient.
- Record advance care plans in a consistent manner (e.g. electronic registries, documentation templates, etc.).
- Integrate resuscitation decisions with other treatment decisions, such as invasive mechanical ventilation, in overarching advance emergency care treatment plans to increase clarity of treatment

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goals and prevent inadvertent deprivation of other indicated treatments.
- Clinicians should not offer CPR in cases where resuscitation would be futile.

Improving communication

- Clinicians should use evidence-based communication interventions to improve end-of-life discussions and support completion of advance directives/advance care plans.
- Clinicians should combine structured end-of-life discussions with video decision aids for shared decision making about end-of-life hospital transfer from nursing homes in systems where this technology is available.
- Clinicians should consider inviting a communication facilitator to join discussions with patients and/or their family when making advance care plans about the appropriateness of life sustaining treatments. This refers to systems where communication facilitators are available.
- Healthcare systems should provide clinicians with communication skills training interventions to improve clinicians' skill and comfort in delivering bad news or supporting patients to define care goals.
- Clinicians should integrate the following patient/family support elements with shared decision making:
  1. Provide information about the patient's status and prognosis in a clear and honest manner. This may be supported by use of a video-support tool.
  2. Seek information about the patient's goals, values, and treatment preferences.
  3. Involve patients/family members in discussions about advance care plans.
  4. Provide empathic statements assuring non-abandonment, symptom control, and decision-making support.
  5. Provide the option of spiritual support.
  6. Where appropriate, explain and apply protocolised patient-centred procedures for treatment withdrawal with concurrent symptom control and patient/family psychological support.
  7. Consider recording meetings with family for the purpose of audit/quality improvement.

Deciding when to start and when to stop cardiopulmonary resuscitation (CPR)

Withholding and Withdrawing CPR

- Systems, clinicians, and the public should consider cardiopulmonary resuscitation (CPR) a conditional therapy.
- Systems should implement criteria for the withholding and termination of CPR for both in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA), taking into consideration the specific local legal, organisational, and cultural context.
- Systems should define criteria for the withholding and termination of CPR, and ensure criteria are validated locally. The following criteria may be considered:
- ○ Unequivocal criteria:
  - When the safety of the provider cannot be adequately assured
  - When there is obvious mortal injury or irreversible death
  - When a valid and relevant advance directive becomes available that recommends against the provision of CPR
- ○ Further criteria to inform decision making:
  - Persistent asystole despite 20 min of advanced life support (ALS) in the absence of any reversible cause.
  - Unwitnessed cardiac arrest with an initial non-shockable rhythm where the risk of harm to the patient from ongoing CPR likely outweighs any benefit e.g. absence of return of spontaneous circulation (ROSC), severe chronic co-morbidity, very poor quality of life prior to cardiac arrest.
  - Other strong evidence that further CPR would not be consistent with the patient's values and preferences, or in their best interests.
- ○ Criteria that should not alone inform decision-making e.g.
  - Pupil size
  - CPR duration
  - End-tidal carbon dioxide (CO2) value
  - Co-morbid state
  - Initial lactate value
  - Suicide attempt.
- Clinicians should clearly document reasons for the withholding or termination of CPR, and systems should audit this documentation.
- Systems should implement criteria for early transport to hospital in cases of OHCA, taking into account the local context, if there are no criteria for withholding/terminating CPR. Transfer should be considered early in the CPR attempt and incorporate patient, event (e.g. distance to hospital, risk of high-priority transport for those involved), and treatment (e.g. risk of suboptimal CPR) factors. Patients who may particularly benefit from early transport include emergency medical services (EMS) witnessed arrest [or by bystander performing high quality basic life support (BLS)] with either ROSC at any moment or ventricular fibrillation/tachycardia (VT/VF) as presenting rhythm and a presumed reversible cause (e.g. cardiac, toxic, hypothermia).
  - ○ Systems should implement criteria for inter-hospital transfer of IHCA patients in hospitals where advanced CPR techniques are not offered.
- Clinicians should start CPR in patients who do not meet local criteria for withholding CPR. Treatments may then be tailored as more information becomes available.
- Clinicians should not partake in 'slow codes'.
- During a pandemic, resource demand (e.g. critical care beds, ventilators, staffing, drugs) may significantly exceed resource availability. Healthcare teams should carefully assess each patient's likelihood of survival and/or good long-term outcome and their expected resource use to optimise allocation of resources. Clinicians should not use categorical or blanket criteria (e.g. age thresholds) to determine the eligibility of a patient to receive treatment.
- In systems that offer uncontrolled donation after circulatory death and other systems of organ donation, transparent criteria should be developed for the identification of candidates and process for obtaining consent and organ preservation.

Bystander CPR

Systems should:

- Recognise the importance of bystander CPR as a core component of the community response to OHCA.
- Recognise bystander CPR as a voluntary act, with no perceived moral or legal obligation to act.
- Support bystanders in minimising the impact on their own health of performing bystander CPR. In the context of transmissible disease (such as Covid-19), bystanders also have a responsibility of preventing further disease transmission to other individuals in the immediate vicinity and the wider community.

Fig. 18 – Ethics Summary infographic.

- Aim to identify cases where bystander CPR is likely to be beneficial and cases where it is unlikely to be beneficial.
- Never evaluate the value of (bystander) CPR in isolation but as part of the whole system of healthcare within their region. (Bystander) CPR seems feasible in settings where resources and organisation support the integrity of the chain of survival.

Family presence during resuscitation

Resuscitation teams should offer family members of cardiac arrest patients the opportunity to be present during the resuscitation attempt in cases where this opportunity can be provided safely, and a member of the team can be allocated to provide support to the patient's family. Systems should provide clinicians with training on how best to provide information and support to family members during resuscitation attempts.

Patient outcomes and ethical considerations

- When making decisions about CPR, clinicians should explore and understand the value that a patient places on specific outcomes.
- Health systems should monitor outcomes following cardiac arrest, and identify opportunities to implement evidence-based interventions to reduce variability in patient outcome
- Cardiac arrest research should collect core outcomes, as described in the cardiac arrest core outcome set.

Ethics and emergency research

- Systems should support the delivery of high-quality emergency, interventional and non-interventional research, as an essential component of optimising cardiac arrest outcomes.
- Researchers should involve patients and members of the public throughout the research process, including design, delivery and dissemination of the research.

- For observational research (e.g. in the context of registry data collection and or DNA biobank data sampling and analyses) we suggest consideration of a deferred and broad consent model, with concurrent implementation of appropriate safeguards aimed at preventing data breaches and patient re-identification.
- Communities or population in which research is undertaken and who bear the risk of research-related adverse events, should be given the opportunity to benefit from its results.
- Researchers must ensure that research has been reviewed and approved by an independent ethical review committee, in line with local law, prior to it being commenced.
- Researchers must respect the dignity and privacy of research subjects and their families.
- Researchers should comply with best practice guidance to ensure transparency of research, including study protocol registration, prompt reporting of results, and data sharing.
- Systems should ensure that funding for cardiac arrest research is proportionate to the societal burden caused by cardiac arrest-associated morbidity and mortality.

Education

These European Resuscitation Council Advanced Life Support (ALS) guidelines, are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. This section provides guidance to citizens and healthcare professionals with regard to teaching and learning the knowledge, skills and attitudes of resuscitation with the ultimate aim of improving patient survival after cardiac arrest.

Key messages from this section are presented in Fig. 19.

The principles of medical education applied to resuscitation

The ERC, as a scientific based organisation, grounds its guidelines on current medical evidence. The same applies for the ERC education guidelines for resuscitation. The ERC approach to education can be grouped into 4 themes (4 'I's): (1) Ideas (theories of education and how we learn), (2) Inquiry (research which both develops from and informs the ideas mentioned), (3) Implementation (approaches based on the research), and (4) Impact (outcome of these educational approaches both for learning and clinical practice).

Resuscitation education for different target groups

Every citizen should learn to provide the basic skills to save a life. Those with a duty to respond to emergencies need to be competent to perform resuscitation, depending on the level of rescue they provide, from BLS to advanced life support, for children and/or adults, according to the current ERC guidelines. Resuscitation competencies are best maintained if training and retraining is distributed over time, and frequent retraining is suggested between two and twelve months. For HCPs, accredited advanced life support training is recommended, as well as the use of cognitive aids and feedback devices during resuscitation training. Specific team membership and team leadership training should be a part of advanced life support courses, and data-driven, performance-focused debriefing needs to be taught.

Key points in resuscitation education for bystanders and first responders are:

- Enhance willingness to perform CPR;
- Reinforce the chain of survival;
- Teach resuscitation using feedback devices;
- Distribute resuscitation training over time (spaced education)
- Maintain resuscitation competencies by frequent retraining.

Key points in resuscitation education for HCPs are:

- Teach every HCP high-quality CPR (from BLS to advanced life support level, children and/or adults, special circumstances depending on the workplace and patient mix);
- Teach accredited advanced life support courses and include team and leadership training in such courses;
- Use cognitive aids;
- Teach and use debriefing.

Teaching the skills to perform high-quality resuscitation

Teaching the technical skills to perform resuscitation on every given level is very important. Equally important, however, is the teaching of human factors: e.g. communication, collaboration in teams and with different professions, awareness of the critical situation, etc. Human factors are crucial to achieving high-quality CPR and good clinical practice. Teaching these factors will increase the willingness of trained responders to help victims in a life-threatening situation, improve the initiation of the chain of survival by starting BLS and gives participants of CPR courses the confidence to attempt resuscitation whenever needed.

Technology enhanced education to teach resuscitation

Learning CPR can be supported by the use of smartphones, tablets, etc. by using apps and social media, as well as feedback devices. These learning modalities may be teacher independent. They improve retention and facilitate competency assessment in CPR. Gamified learning, (e.g. virtual and augmented reality, tablet apps simulating monitors, etc.) may engage many learners. Virtual learning environments are recommended to be used for pre-course e-learning, as part of a blended learning approach, or for self-learning options of learning independent of time and location for all levels of CPR courses.

Simulation to educate resuscitation

High as well as low fidelity simulation in resuscitation education facilitates contextualised learning for a variety of learners. It integrates technical and non-technical skills and considers the environment or context of specific learner groups and the different levels of expertise. Hence, simulation provides the opportunity to learn to deal with human factors in critical situations. Specific team or leadership training should be included in advanced life support simulation. Profound learning occurs during the reflection phase in the debriefing of a simulated resuscitation.

Faculty development to improve education

In many areas of education, the quality of the teacher has a major impact on learning, and this can be improved by training and ongoing faculty development. The evidence for these effects in resuscitation training is scarce and many recommendations on faculty development are therefore extrapolated from other areas. Three aspects of faculty development are important: selection of suitable instructors, initial instructor training, and maintenance and regular update of their teaching quality.

Effect of resuscitation education on outcome

Accredited ALS training and accredited neonatal resuscitation training (NRT) for HCPs improve the outcome of patients. The effect of other

Fig. 19 – Education summary infographic.

life support courses on patient outcome is less clear, but it is reasonable to recommend other accredited life support courses. Further research is needed to quantify their actual impact on patient outcomes.

Research gaps and future directions in educational research

There is a lack of high-quality research in resuscitation education to demonstrate whether CPR training improves process quality (e.g. compression rate, depth or fraction) and patient outcomes (e.g. return of spontaneous circulation, survival to discharge or survival with favourable neurological outcome). Successful strategies to improve educational efficiency from the wider medical education literature should be considered to study their value for resuscitation education. Contextualised and tailored CPR training can prevent the decay of resuscitation competency. There is a potential for resuscitation courses to become less generic and to focus more on individual needs of the learner. Future research areas include investigating optimal training and support provided to resuscitation trainers and the role of education in reducing emotional and psychological trauma to the rescuer.

Conflict of interest

JN reports funding from Elsevier for his role as Editor in Chief of the journals Resuscitation and Resuscitation Plus. He reports research funding from the National Institute for Health Research in relation to the PARAMEDIC2 trial and the AIRWAYS2 trial.

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JTG declared speakers honorarium from Weinmann, Fresenius, Ratiopharm, Zoll; he is Scientific Advisor for Zoll Temperature management.

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Appendix A. European Resuscitation Council Guideline Collaborators

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Appendix B. Supplementary data

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