Special Article

Comprehensive cardiopulmonary life support (CCLS) for cardiopulmonary resuscitation by trained paramedics and medics inside the hospital

Address for correspondence:
Dr. Syed Moied Ahmed,
Department of Anaesthesiology
and Critical Care, J N Medical
College, Aligarh Muslim
University, Aligarh,
Uttar Pradesh, India.
E-mail: sma99@rediffmail.com

Rakesh Garg, Syed Moied Ahmed[1], Mukul Chandra Kapoor[2], SSC Chakra Rao[3], Bibhuti Bhusan Mishra[4], M Venkatagiri Kalandoor[5], Baljit Singh[6], Jigeeshu Vasishtha Divatia[7]

Department of Onco-Anaesthesiology and Palliative Medicine, Dr BRAIRCH, All India Institute of Medical Sciences, [6]Department of Anaesthesiology and Intensive Care, GB Pant Institute of Postgraduate Medical Education and Research, [2]Department of Anesthesia, Max Smart Super Specialty Hospital, New Delhi, [1]Department of Anaesthesiology and Critical Care, J N Medical College, Aligarh Muslim University, Aligarh, Uttar Pradesh, [3]Department of Anaesthesiology, Care Emergency Hospital, Kakinada, Andhra Pradesh, [4]Department of Anaesthesiology, Indian College of Anaesthesiologists, Bhubaneswar, Odisha, [5]Department of Anaesthesiology, Government General Hospital, Kasaragod, Kerala, [7]Department of Anaesthesia, Critical Care and Pain, Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, Maharashtra, India

ABSTRACT

The cardiopulmonary resuscitation (CPR) guideline of comprehensive cardiopulmonary life support (CCLS) for management of the patient with cardiopulmonary arrest in adults provides an algorithmic step-wise approach for optimal outcome of the patient inside the hospital by trained medics and paramedics. This guideline has been developed considering the infrastructure of healthcare delivery system in India. This is based on evidence in the international and national literature. In the absence of data from the Indian population, the extrapolation has been made from international data, discussed with Indian experts and modified accordingly to ensure their applicability in India. The CCLS guideline emphasise the need to recognise patients at risk for cardiac arrest and their timely management before a cardiac arrest occurs. The basic components of CPR include chest compressions for blood circulation; airway maintenance to ensure airway patency; lung ventilation to enable oxygenation and defibrillation to convert a pathologic 'shockable' cardiac rhythm to one capable to maintaining effective blood circulation. CCLS emphasises incorporation of airway management, drugs, and identification of the cause of arrest and its correction, while chest compression and ventilation are ongoing. It also emphasises the value of organised team approach and optimal post-resuscitation care.

Key words: Cardiopulmonary resuscitation, inside the hospital, chest compression, defibrillation, airway management, drugs in cardiopulmonary resuscitation

DISCLAIMER

This guideline has been made to improve the outcome of the patient with cardiopulmonary arrest. The guideline presents a streamlined algorithmic approach using evidence-based recommendations. Consensus opinions from experts are used, wherein robust Indian data were not available. However, these consensus statements remain based on inputs from international data and suitability modified to overcome the infrastructural and economic restrictions in India. It is emphasised that these guidelines do not represent the minimum standard of practice, nor are they a substitution for the good clinical judgment.

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PREAMBLE

The optimal outcome of a patient after cardiac arrest inside the hospital depends on not only the basic resuscitation steps but also the incorporation of advanced steps including administration of drugs, airway management, correction of underlying aetiologies, advanced monitoring and post-resuscitation care.[1-7] In the absence of a robust pre-hospital medical transfer system in India, many patients are brought by the family members and may not have received optimal medical care. Cardiopulmonary arrest can occur in any part of the hospital ranging from a well-equipped critical care unit to lesser-equipped peripheral wards and outpatient clinics. Such patients require comprehensive management of the cardiac arrest starting from basic steps and thereafter incorporating advanced care at the earliest. The comprehensive cardiopulmonary life support (CCLS) emphasises five core links for an optimal outcome in a patient with cardiac arrest. Early comprehensive life support has been incorporated as the fifth link in core links in adult CCLS. Hence, considering this, a comprehensive approach is required, which incorporates all steps of cardiopulmonary resuscitation (CPR) in a single algorithm. Time is of the essence during resuscitation! The resuscitation trolley such as crash cart, with all essential equipment, may take time to shift even in hospitals, especially to peripheral wards. Therefore, it becomes essential that medical personnel available immediately initiate basic resuscitation to start the process. Patients also require post-resuscitation care to manage underlying aetiologies, neurological injuries and refractory cardiac arrest, and prevent complications of resuscitation attempts., This CCLS guideline encompasses all the steps of resuscitation, after cardiac arrest inside the hospital, with an aim to integrate the basic and advanced components of CPR.

METHODS

The detailed methodology has been discussed earlier in section on basic cardiopulmonary life support (BCLS).[8]

Search strategy

A list of resuscitation-related search terms was identified. A literature search for studies published in English language between June 2005 and June 2017 using PubMed, Embase, Medline, Ovid, Google Scholar Databases and other search engines using the following search items and key words: CPR; inside the hospital cardiac arrest; defibrillation; automated external defibrillation; early defibrillation; high-quality CPR; chest compression; early transfer; pulse check for cardiac arrest; airway management; drugs; reversible causes; antiarrhythmics; trained personnel in different combinations. Additional articles were retrieved by cross-referencing and manual search of the desired manuscripts. The main focus was on randomised clinical trials, but observational cohort studies and case reports/series were also identified. A total of 3985 abstracts were reviewed for relevance, and this list was narrowed down to 79 articles for detailed study. In addition, CPR guidelines of various societies were reviewed. Articles specifically related to the individual guideline were circulated to the experts. Each article was reviewed by at least two members of the resuscitation Group.

COMPREHENSIVE CARDIOPULMONARY LIFE SUPPORT (CCLS) LINKS AND ALGORITHM DESCRIPTION

Core links in adult comprehensive cardiopulmonary life support (CCLS)

The five essential core links for optimal outcome in patient with cardiopulmonary arrest during CCLS are [Figure 1]:

- Early recognition and management of pre-arrest conditions
- Early recognition of arrest and activation of Code blue
- Early high-quality CPR
- Early defibrillation
- Early comprehensive life support and post-resuscitation care.

These links remain the focus for improved outcome in CCLS. The early identification of pre-arrest conditions and appropriate management are essential to prevent cardiac arrest in the controlled environment of a hospital. The early recognition and delivery of high-quality CPR by a dedicated team are the most important aspects of the links in CCLS. The role of early defibrillation is paramount in a patient with sudden collapse due to a cardiac cause. After basic resuscitation, the patient requires further assessment and management, to correct the underlying aetiology, to prevent re-arrest and minimise the damage that would have occurred during the arrest period and resuscitation.

Adult comprehensive cardiopulmonary life support (CCLS) steps

The management of a patient with cardiopulmonary arrest inside the hospital requires a systematic
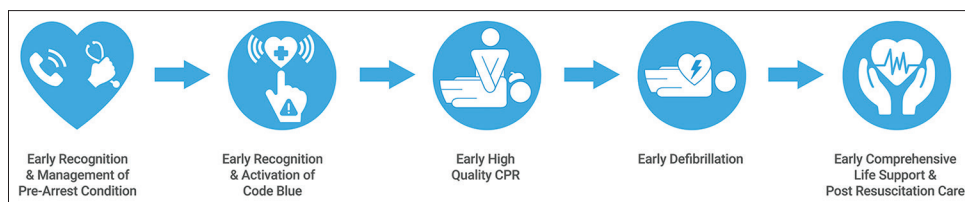
Figure 1: Core links in adult comprehensive cardiopulmonary life support (CCLS)

approach for an optimal outcome. A sequential series of predefined steps, for the assessment and management of the arrest patient, must be followed to ensure return of spontaneous circulation (ROSC). The CCLS is a simplified algorithm-based approach to be followed to resuscitate a patient with cardiopulmonary arrest [Figure 2]. Although the algorithm of CCLS is sequential, these steps may be done simultaneously as more than one trained person are usually available in a hospital. However, the ethos of the algorithm needs to be followed. The division of work needs to be done in such a way that the patient gets care at the earliest while all steps are being followed. The steps of CCLS are:

Safe place for resuscitation

The place usually remains safe inside the hospital. However, in certain situations, patient may have collapsed while not in bed or in emergency or may be in outpatient department. The patient should be shifted immediately to safe place, wherein CPR could be performed optimally. However, delay in shifting or starting CPR should always be avoided. All places inside the hospital are suitable for CCLS and no specific area is being suggested in this guideline. Once the patient has been shifted to suitable place, the assessment and resuscitation of the patient should be initiated at the earliest.

Patient's response check

The patient's response check needs to be done immediately. The rescuer should come from front facing the patients face, tap on the shoulder, speak loudly (e.g., Hello-Are You Alright?) in a language patient could understand to elicit the response from the patient. The patient should not be shaken and neck movements done (such as tapping on face) should not be done as they could cause further harm in cases of injury to cervical spine, if present. Two situations arise:

- Responsive: If the patient responds either verbally and/or by purposeful movement, then there is less likelihood of cardiopulmonary arrest. Such a patient needs to be monitored frequently. He may be shifted to high dependency unit or a monitored area and further evaluation needs to be done

- Not Responsive: If no response is elicited, then patient may be in cardiac arrest. Additional help is required, and hence, Code blue team or local team (as in Intensive care unit or other dedicated area) needs to be activated.

Activate Code blue team or local team

The person observing the patient collapsing should immediately activate the Code blue or inform the local team as per institutional protocol. All hospitals should assign a Code blue speed dial number in their internal telephone exchange, and the Code blue number must be prominently displayed in all areas of the hospital. In case help is available, he may be instructed to activate the Code blue or local team and inform them to bring defibrillator and emergency crash cart (emergency drugs and equipment including venous access, airway management equipment, etc.). The resuscitation team must be defined, based on the duty roster, and their contact details must be prominently displayed for immediate contact in case of Code blue.

Check pulse and breath simultaneously

After activation of Code blue, the pulse and breathing should be assessed simultaneously. The carotid pulse should be identified and checked for its definite presence. The pulse needs to be checked for 5–10 s. During this pulse check, the chest should also be scanned for breathing movements. The absence of breathing or abnormal breathing such as gasping or agonal breaths and absence of definite carotid pulse are suggestive of cardiopulmonary arrest. In case of doubtful presence of pulse and breath, the patient should be assumed to have cardiopulmonary arrest. The check for pulse and breath should not take >10 s. The timing for 10 s may be done by chanting loudly 1001, 1002, 1003,….1010 to avoid delay for an initiation of 'early CPR'. During the check of pulse and breath, three situations may be arise:

- Normal breathing with definite carotid pulse: the patient needs to be assessed every 2 min or more frequently for some change in vital parameters. Patient may be shifted to high dependency unit or intensive care set-up for
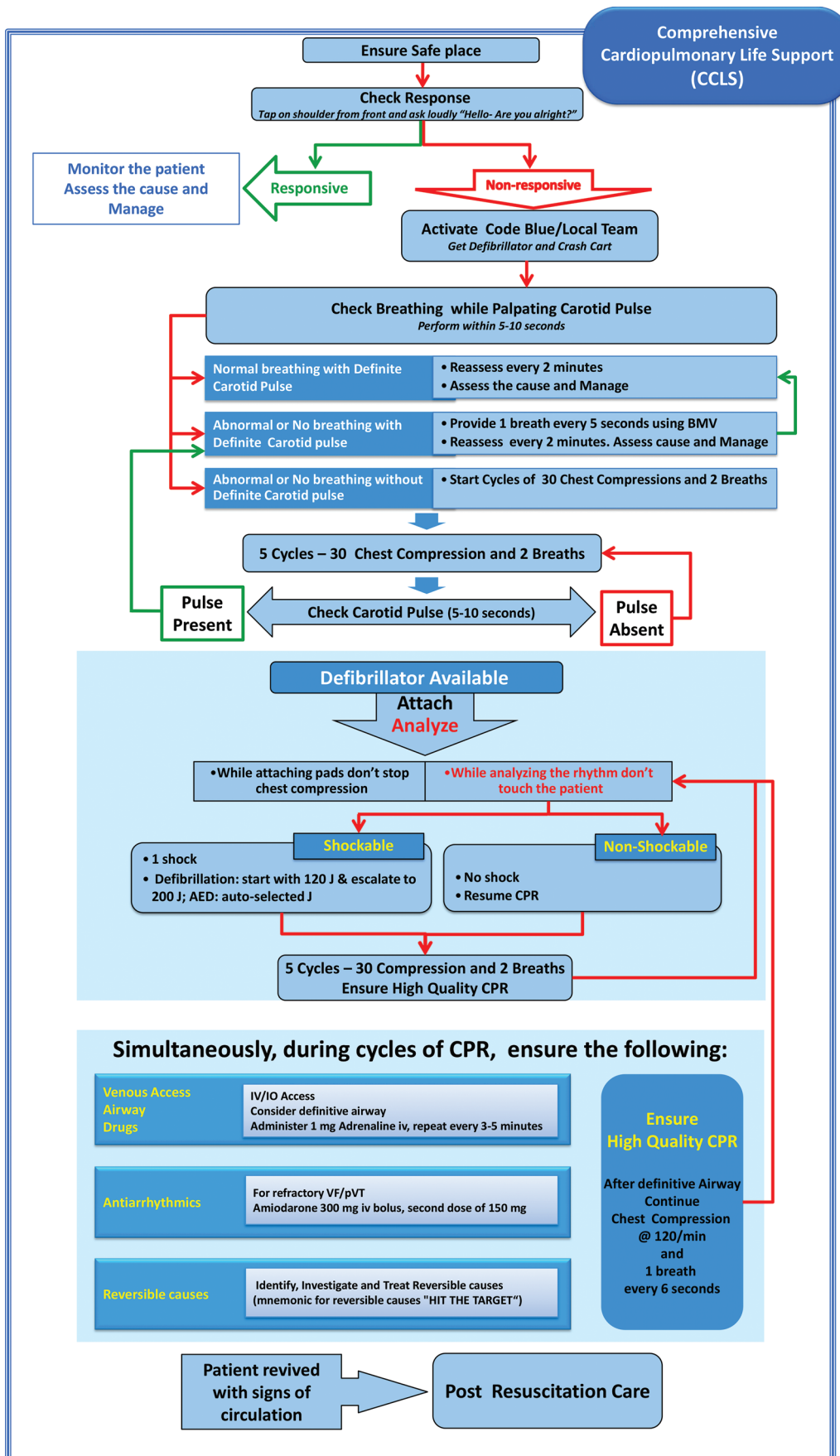
Garg, *et al*.: Comprehensive cardiopulmonary life support (CCLS)

Figure 2: Comprehensive cardiopulmonary life support (CCLS) algorithm

continuous monitoring, and further evaluation for cause of collapse and its management

- Abnormal or no breathing with a definite carotid pulse: the patient is in respiratory arrest. After opening of the airway by head tilt and chin lift (only jaw thrust or chin lift in victim of suspected cervical spine trauma), a normal tidal volume breath should be provided (end point is visible chest rise) every 5 s (12 breaths every minute) using bag-mask device. The use of oropharyngeal or nasopharyngeal airway devices may be used in case ventilation using bag-mask device is not optimal. In case expertise is available, then the airway may be secured using endotracheal tube and ventilation continued using bag-mask device. Each breath should be delivered over 1 s. Reassess the patient for pulse every 2 min or earlier for change in the vital parameters. Evaluate the patient for the cause of respiratory arrest and manage accordingly

- Abnormal or no breathing without a definite carotid pulse: the patient is in cardiopulmonary arrest and requires high-quality CPR at the earliest.

Early high-quality cardiopulmonary resuscitation

Once the cardiopulmonary arrest is recognised, the cycles of 30 chest compressions and 2 breaths should be initiated. To ensure optimised chest compressions, patients should be placed supine on a hard bed, on the ground or a hard board may be slipped behind the back of the patient to prevent backward movement of the vertebral column during the compressions.

Chest Compressions: The 30 chest compressions should be started at the speed of 120 compressions/min and compression depth of 5 cm–6 cm. The rescuer should chant loudly 1, 2, 3, 4,....30 to optimise the speed and number of chest compressions. The rescuer should allow complete chest recoil between compressions without lifting the hand from the chest but without leaning on the patient's chest. To ensure optimal chest compression, the rescuers should position himself higher than the patient; interlock his hands; place the palmar surface of his hand on the centre of chest by identifying the xiphoid process and keeping heel of the hand 2 fingers above it for chest compressions, and ensure that the elbows are locked in extension so that his body weight rather arm movements facilitate the compression. There should be minimum interruptions between chest compressions

Breaths: Once chest compressions have been initiated, rescue breaths need to be delivered using a self-inflating bag-mask device. Bag-mask ventilation (BMV) involves keeping a triangular, cushioned, well-fitting mask covering the mouth and the nose, with the apex of the triangular mask resting on the bridge of the nose. The mask is connected to a compressible, self-inflating bag (with unidirectional valve) that is connected to a source of high flow oxygen. Selection of the correct size mask and achieving a proper mask seal is important to ensure adequate ventilation. BMV ventilation may be facilitated by performing a triple airway manoeuvre and/or insertion of basic airway adjuncts such as nasal or oral airways, in case adequate chest rise is not achieved. Each tidal volume breath should be delivered over 1 s with end point of visible chest rise. After allowing 1 s for exhalation, another breath over 1 s is provided and thereafter chest compression should be immediately restarted to minimise interruption in chest compressions.

The rescuer providing chest compressions and the one providing breath should interchange their role after every 5 cycles of CPR to prevent rescuer exhaustion and to maintain effective CCLS, especially chest compression. After 5 cycles of 30 chest compressions and 2 breaths*, the patient should be reassessed with carotid pulse check#. During the pulse check, the possible situations are:

Pulse present: Check for the presence of breath. If absent, provide breath every 5 s and reassess every 2 min. In case of the presence of breath, reassess every 2 min and shift the patient to a monitored area and correct the underlying aetiology

Pulse absent: Continue with another 5 cycles of 30 chest compressions and 2 breaths and reassess the carotid pulse.

*In case the patient's airway is already secured with an endotracheal tube, then chest compressions should be given continuously at a rate of 120 compressions/min without interruption, and 1 breath should be delivered every 6 s (10 breaths/min), rather than cycles of 30 chest compressions and 2 breaths. The rescuer performing compressions must rotate, approximately every 2 min, to ensure high-quality CPR.

In case cardiac monitor or defibrillator pads/paddles are attached to the patient, then cardiac rhythm should be checked on the monitor instead of pulse. Based on

rhythm assessment, need for defibrillation should be decided. However, pulse check may still be required in certain situations such as confirmation of an organised rhythm without a pulse (pulseless electrical activity [PEA]) and to differentiate ventricular tachycardia (VT) with/without pulse.

Early defibrillation

Defibrillation should be done at the earliest, especially in patient with witnessed sudden cardiac arrest. Defibrillation can be provided using a manual defibrillator. Till the arrival of the defibrillator and its attachment, high-quality CPR should be ensured. The first shock should be administered at the earliest, irrespective of the stage of the ongoing CPR cycle. Thereafter, the defibrillation should be done after 5 cycles of 30 compressions and 2 breaths. Once the defibrillation or cardiac monitor is attached, the pulse check should be replaced by rhythm check on the monitor.

Defibrillator: Follow the steps to prepare for defibrillation:
1. Switch on the defibrillator
2. Attach electrocardiogram (ECG) leads of the defibrillator or keep paddles on the chest (one at apex of heart at left side of the chest and other below the clavicle on the right side in midclavicular line). Continue CPR during lead attachments
3. Analyse the rhythm. No rescuer should touch the patient during rhythm analysis
4. If the rhythm is shockable (ventricular fibrillation [VF] and pulseless VT), charge the defibrillator at 120 J (biphasic). Continue chest compression during charging. Deliver the shock after ensuring that no rescuer is touching the patient or his bed. After delivery of the shock, resume CPR, starting with chest compression. Subsequent shock may be same or escalated to higher dose with maximum of 200 J (biphasic). In case of monophasic defibrillator, the initial and subsequent energy for defibrillation should be 360 J
5. If rhythm is non-shockable (asystole and PEA), then immediately resume CPR cycles starting with chest compressions.

While the cycles of CPR are in process, other advanced aspects such as venous access, airway management, and drug administration should be integrated with cycles of CPR as early as possible. Simultaneously, identify the possible cause of cardiac arrest, send suitable investigations based on possible aetiology and treat accordingly. It needs to be emphasised during all these advanced management, the cycles of CPR should continue with minimal interruption in chest compression.

Venous access

Venous access should be secured during ongoing chest compression and ventilation. The peripheral venous access is the most preferred. In case the venous access is not secured in initial 3 attempts, then the second choice remains intraosseous (IO) cannulation. All drugs and fluids may be administered through the IO route similar to intravenous access. However, it should be replaced with intravenous access at the earliest. In the absence of both of these accesses, the drugs may also be administered through endotracheal route (if already intubated). These drugs include naloxone, adrenaline, atropine and lidocaine. The intratracheal dose should be 2–2½ times that of intravenous dose and diluted to 10 mL.

Airway management

The definitive airway may be secured with an endotracheal tube in case expertise is available. The use of supraglottic devices is also advocated if rescuer is appropriately trained and endotracheal tube placement is not feasible or successful. The correct placement of these devices must be verified after their placement. The use of end-tidal capnography is recommended to verify their correct placement. However, if the BMV is optimal, then securing definitive airway can be deferred to prevent unnecessary interruption of chest compression. In such cases, BMV should be continued till expert help arrives.

Drugs including antiarrhythmics

Once the vascular access is secured, adrenaline (epinephrine) 1 mg diluted in 10 mL should be administered as bolus, irrespective of the type of heart rhythm. This bolus needs to be repeated every 3–5 min. All drugs administered through peripheral venous access must be flushed with 20 mL of normal saline. Whenever feasible, the limb should also be elevated for 10–20 s after administration of the drug to facilitate its passage to the central circulation. Drugs should be administered during chest compression, so as to ensure their systemic distribution. If arrhythmias persist even after initial 2–3 cycles of CPR, then antiarrhythmics drugs are warranted. Amiodarone 300 mg should be administered intravenous as a slow bolus. A second intravenous dose of amiodarone 150 mg may be administered if

arrhythmia persists. Lignocaine may be considered as an alternate drug in patients with persistent arrhythmia.

Assess and manage the reversible causes

The underlying aetiology of the cardiorespiratory arrest needs to be assessed. The history and physical examination needs to be reviewed for possible underlying aetiologies. The medical record and history from patient attendants needs to be reviewed. Based on the findings, the appropriate investigations should to be performed. However, it needs to be emphasised that during this process, the chest compressions and other aspects of resuscitation must not be interrupted. The patient should not be transported to another location for imaging or any special investigation while chest compression is ongoing.

The common causes for a cardiorespiratory arrest include hypovolaemia, hypoxia, acidosis, electrolyte imbalance, pneumothorax, cardiac tamponade, drug toxicity, pulmonary embolism and myocardial infarction. They need to be primarily addressed on clinical examination and blood investigations.

Transfer

After successful resuscitation, the patient needs definitive medical care and management for underlying aetiology of the cardiopulmonary arrest. Patient should be shifted to a high dependency unit or critical care unit. If the cause of cardiac arrest is underlying neurological or cardiac disease, the patients may be shifted to speciality setting of the hospital for an appropriate early intervention and optimal recovery. The patient should receive appropriate post-resuscitation care.

Post-resuscitation care

Once there is ROSC, patient requires specific care in a dedicated unit. During this period, not only are maintenance of perfusion and oxygenation paramount but also the correction of precipitating cause of cardiac arrest needs to be addressed. Ventilatory support may be continued as per patient assessment to maintain normocarbia (end-tidal CO_2 35–40 mmHg). During resuscitation, highest oxygen concentration is recommended but after return of circulation, the inspired fraction of oxygen (Fio_2) should be titrated to maintain oxygen saturation at 95% or more. These ventilatory parameters and targets may be tailored as per patient need. Specialist consultation is essential for assessment for the need of coronary or neurological interventions. The haemodynamic monitoring should be initiated with a target of mean arterial pressure of >65 mmHg. The

optimal blood pressure should be ensured for optimal perfusion of vital organs. In case, if patient remains comatose after resuscitation, active warming must be avoided. Temperature may be kept not >36ºC and not necessarily in the range of 32ºC–36ºC, in the absence of controlled hypothermic equipment. Prophylactic antiepileptic drugs are not recommended but, if seizures occur, then drug therapy should be initiated.

Quality assurance of comprehensive cardiopulmonary life support (CCLS) conduct

High-quality CCLS, and not just following the steps of CCLS, is paramount for an optimal outcome after a cardio-respiratory arrest. Emphasis on continued real-time quality check for CPR is essential. The various aspects that enhance the outcome include:

Chest Compressions
1. Chest compressions speed, rate and recoil: Ensure a chest compression speed of 120 compressions/min to a depth of 5–6 cm
2. Allow complete chest recoil between compression without lifting hands from the chest (do not lean on the patient's chest)
3. Do not stop chest compressions unnecessarily.

Ventilation and Airway
1. Do not unnecessarily interrupt chest compression for securing the airway
2. Do not hyperventilate
3. End point for ventilation is visible chest rise after a normal tidal volume breath.
4. Monitor end-tidal capnography, if available. If it is <10 mmHg, then the CPR quality is inadequate and needs improvement.

If intra-arterial pressure monitoring is available or feasible, then relaxation phase pressure (diastolic) <20 mmHg indicates inadequate chest compression and needs improvement.

DISCUSSION

Good quality CPR, with early defibrillation, early correction of underlying aetiology and effective post-resuscitation care are essential to improve the neurological recovery after cardiac arrest.[9-13] The management of cardiopulmonary arrest inside the hospital is different as compared to that outside the hospital as expert workforce, with better infrastructure and other support, is available.[9,10] The aetiology in an admitted patient is varied as compared to a victim outside

the hospital, who has sudden loss of consciousness and cardiac arrest. Thus, a stand-alone management plan is needed for patients having cardiopulmonary arrest inside the hospital. The CCLS is a step-wise algorithmic approach to manage a patient with cardiopulmonary arrest inside the hospital. It is designed for trained personnel (medics and paramedics) with adequate skill and knowledge, who have basic infrastructure support available. The proposed CCLS algorithm is recommended to be followed for patients with cardiac arrest inside the hospital. The use of automated mechanical CPR devices is not being elaborated, as the same are not available in most parts of India.

The prevention of cardiac arrest should be a priority in admitted patients.[14-16] This could be encouraged by appropriate surveillance system and identification of at-risk patients.[17-19] The first core link of CCLS is early recognition and management of pre-arrest conditions.

Hence, admitted patients having risk factors for cardiac arrest should be identified and corrective measures taken before the cardiac arrest occurs. The cardiac arrest is usually preceded by deterioration in physiological instability including abnormal vital signs such as tachypnoea, tachycardia and hypotension. These pre-arrest conditions should be identified and timely corrective measures should be initiated. Patient being managed in general wards usually have less direct observations and intense monitoring and thus remains at risk of cardiac arrest. Strategies need to be developed for early recognition of high-risk patients and the management of underlying aetiology.

The initial steps for the management of CCLS remain similar as described in section on BCLS.[8] The basic components include effective chest compressions to maintain perfusion of vital organs, airway maintenance to achieve the patent airway, ventilation of the lungs for optimal cellular oxygenation and defibrillation to convert a shockable rhythm to perfusing rhythm. A system should be in place for prompt activation of the resuscitation team along with the crash cart (including drugs, airway equipment and defibrillator) to be brought to the site of cardiac arrest at the earliest. The call for help is sought from hospital teams which may be named as code blue or local team in an intensive care set-up or other similar dedicated places. The response check, checking of pulse and breathing in a time-bound manner is similar to BCLS. The chest compression depth, rate, breaths and other related quality check of CPR remains the same as discussed

in BCLS. In hospitals, manual defibrillator is usually used for reverting the abnormal cardiac rhythm. The assessment, delivery of shock remains the same as described for manual defibrillator in BCLS.

The pulse check should be done at the beginning to ascertain cardiac arrest and thereafter following every 5 sets of CPR. Once the defibrillator is available, the pulse check should be replaced with rhythm analysis after every 5 sets of CPR. In patients on ECG monitoring, rhythm must be assessed on monitor rather than by pulse check. Interruption to chest compression during rhythm analysis or pulse check should be <10 s. Pulse check is warranted in addition to rhythm analysis in clinical conditions such as VT or organised rhythm to ascertain the presence and absence of pulse. In case a flat line is seen on the monitor, a quick check within 10 s should be performed for lead connections, mode of monitor (paddle vs. lead mode), gain or amplitude to verify true asystole or fine VF. It is warranted not to stop chest compression, to assess rhythm during the 5 sets of CPR, even if the patient is not on continuous rhythm monitoring.

Airway management during resuscitation

The goal for the airway management during CPR is to ensure a patent airway and oxygenation.[20] A decade back, the priority sequence of Airway ⇒ Breathing ⇒ Circulation (ABC) was replaced by Circulation ⇒ Airway ⇒ Breathing (CAB).[21,22] The regular use of cricoid pressure is not suggested in these guidelines.[23] There are differing views on the need, type and equipment for airway management during CPR.[24-26] Airway management is a highly skilled and operator-dependent arm of resuscitation.[27] It is essential that the chest compressions should either not be interrupted at all or interrupted <10 s during airway management. The healthcare professionals should be well versed with basic airway management as it is crucial for maintaining airway patency and providing breaths. Basic airway management consists of manual relief of upper airway obstruction ('Triple airway manoeuvre'), BMV or the insertion of oropharyngeal or nasopharyngeal airway.[28,29]

It is suggested that maximal inspired oxygen concentration, at high flows, be provided to all patients.[30] In a retrospective resuscitation study, Bobrow *et al.* found significantly higher survival without neurological deficit with passive oxygen insufflation as compared to positive pressure BMV.[30] Better survival and neurological outcomes have also been reported with BMV ventilation as compared to use of advanced

airway insertion (endotracheal tube and laryngeal mask airway [LMA]) in studies from Korea and Japan.[31,32]

The two goals of advanced airway management are control of oxygenation/ventilation and airway protection from aspiration of vomitus, secretions, blood or gastric contents.[26] Advanced airway are indicated for airway protection as apnoeic patients lack protective reflexes. BMV is recommended in a cardiac arrest patient, not tracheally intubated, until trained help arrives.[6] Alternative airway adjuncts were incorporated in cardiac arrest resuscitation to reduce 'hands-off' times during CPR. They include insertion of a supraglottic airway device (SAD), endotracheal tube, Combitube or cricothyroidotomy.[6]

The chest compression fraction (CCF) (proportion of CPR time spent providing chest compressions) greatly influences the survival after cardiac arrest and CPR.[33] CCF should be above 0.6 to ensure the probability of a successful CPR. Gaszynska *et al*. reported better mean CCF with LMA Supreme and Combitube use compared to endotracheal tube.[34] Although endotracheal intubation provides both oxygenation/ventilation control and airway protection, it is associated with several complications in cardiac arrest situations.[35] The rescuer should ask for momentary interruption of chest compressions to facilitate tracheal intubation only if absolutely required. Such interruptions should not exceed 10 s. Videolaryngoscope, if available, may be used for better success rate and reduction in complications.

Difficult airway (DA) can arise during intubation, SAD placement or BMV ventilation. Chest compressions should never be stopped for the DA assessment or management. If direct laryngoscopy and intubation is difficult, a SAD should be promptly inserted to maintain oxygenation and ventilation. It is best to continue with BMV combined with chest compressions till expert help arrives. 'Cannot ventilate, cannot intubate' situations are difficult to manage and it is best to administer high flow oxygen through a face mask and continue with 'compression-only life support' (COLS) till experienced rescuers arrive.[36] More randomised, controlled trials are needed to recommend management of DA with cardiac arrest. Surgical cricothyroidotomy is a life-saving procedure for DA management.[37]

The correct placement of endotracheal tube should be ascertained using clinical signs (such as bilateral chest expansion and five-point auscultation starting from epigastrium) and waveform capnography.[38]

The other alternatives could be oesophageal detector devices, carbon dioxide detectors or ultrasound by an experienced person.[39-42] Subsequently, endotracheal tube placement must be rechecked on X-ray. ROSC is indicated during CPR as a sudden increase in the end-tidal carbon dioxide.[43-47] Further trials are required to assess the value and role of capnography in cardiac arrest situations using BMV or SAD.

There is some evidence of providing breaths at equal interval rather than in sets of 30 compressions and two breaths during resuscitation.[1,2] Till there is concrete evidence on synchronisation of compressions and breaths, we suggest continuing sets of 30 compressions and 2 breaths till the advanced airway is placed. Thereafter, synchronisation is not required and the chest compression is continued at 120 compressions/min and 1 breath every 6 s.

Vascular access and drugs

Most of the admitted patients in the hospital have venous access which should be used. In case it is not available, it should be secured once CPR has been started. Peripheral large calibre veins are suggested for venous access. Alternate access could be through the IO routes at sites such as humerus, proximal/distal tibia and sternum.[48] The proximal tibia appears to be the most suitable site. At times central venous access may be present, then it should be preferably be used to shorten transit of drugs to the central circulation.[24,49,50] However, central venous access should not be attempted, if not already present, as it may interrupt chest compression and also because it requires expertise. The endotracheal route use is discouraged but it can be used as desperate measure.

The comprehensive management during CPR requires use of drugs.[51-55] Robust evidence to use various drugs during CPR is lacking. Adrenaline remains the drug of choice in all arrested cardiac rhythms.[56-59] One mg of it should be administered and repeated every 3–5 min, whereas ongoing chest compression for its distribution to central circulation. In case of refractory VF and pulseless VT (not responding or recurs after 2–3 defibrillation shock), antiarrhythmic agents such as amiodarone (300 mg as first bolus and repeat 150 mg if required) needs to be administered.[51,52,60] Alternate to amiodarone could be lidocaine (1–1.5 mg/kg slow bolus).[52] Routine use of drugs such as sodium bicarbonate, calcium or glucose is not recommended but they may be used if indicated, based on the assessment and underlying aetiology.

Reversible causes

Identifying the underlying aetiology and its correction is important for an optimal outcome after CPR.[61,62] The more common causes requiring assessment and management can be remembered with the mnemonic 'HIT THE TARGET" (H – Hypoxia, I – Increased H Ions [Acidosis], T – Tension Pneumothorax, T – Toxins/Poisons, H – Hypovolaemia, E – Electrolyte Imbalance [Hypo-/Hyperkalaemia], T – Tamponade Cardiac, A – Acute Coronary Syndrome, R – Raised Intracranial Pressure [Subarachnoid Haemorrhage], G – Glucose [Hypo-/hyperglycaemia], E – Embolism (Pulmonary Thrombosis), T – Temperature [Hypothermia]). In a hospital setting, many other cardiac and non-cardiac causes could also lead to cardiac arrest and should also be sought based on pre-existing clinical diagnosis, history, clinical signs and appropriate investigations. Blood sample should be sought during the venous cannulation itself. Ultrasound has been used as bedside tool for the assessment of the cause of arrest, but it requires expertise and its routine use is not recommended in the present guidelines.[6]

Monitoring

During CPR, it is not only essential to monitor the quality of rescuers performance (like chest compression quality) but also patient physiological parameters to ascertain overall optimisation of CPR.[63,64] Monitoring like end-tidal CO_2 (EtCO$_2$), central venous pressure, central venous oxygen saturation and arterial blood pressure are important to ascertain the CPR quality and its outcome.[16,41-43] The abrupt increase in their values is suggestive of ROSC.[46,65-67] Urine output is an important monitor for ascertaining perfusion after ROSC.[68] Ultrasound has also been reported a bedside repeatable monitoring tool.[69,70] Blood gas values are difficult to interpret during CPR.

Duration of cardiopulmonary resuscitation

CPR discontinuation should be based on clinical condition of the patient.[71-74] Once the reversible causes have been ruled out and/or corrected, based on clinical judgment and a careful assessment, a decision may be taken to discontinue CPR. The presence of rhythm such as VF/pulseless VT should prompt to continue the resuscitation attempts. EtCO$_2$ has been suggested a good sign of perfusion and thus can be used for prognostication in intubated patients. It may be suggested that with high-quality CPR and rhythm as asystole for >20 min, EtCO$_2$ <10 mmHg may be considered a sign to forgo further attempts. In patients without such monitoring, a definite time frame is not suggested and duration should be based on clinical decision. The final decision to start and stop resuscitation would also be based on the overall clinical assessment. Patient receiving palliative care or end-of-life care should be carefully chosen for initiation of resuscitation.[75,76]

Post-resuscitation care

The patient should receive post-resuscitation care once there is ROSC.[77] Patients should be shifted to a monitored area and further definitive management of the underlying aetiology should be started. Since cardiac cause is one of the important contributors, consultation for coronary intervention should be sought at the earliest. CPR may lead to hypoxic insult to various organ systems including brain. Oxygen supplementation and ventilation support should be provided based on the post-resuscitation assessment. The haemodynamic monitoring is essential, and the mean arterial pressure should be maintained >65 mmHg.[5,6] At present, controlled hypothermic equipment are not easily available in India. The need of hypothermia should be assessed if the necessary equipment is present. However, active warming should not be started.

CONCLUSION

The management of patient of cardiopulmonary arrest inside hospital requires early recognition along with early high-quality resuscitation, including defibrillation. Following the core links of CCLS in adult resuscitation would improve the overall outcome. CCLS emphasises providing high-quality resuscitation, simultaneously looking for the cause of cardiac arrest and correcting the reversible cause, while continuing resuscitation.

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