28 May 2021
No. 10

ATTITUDES AND APPROACH TO INTRA-OPERATIVE CARDIAC ARREST

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INTRODUCTION

While many of our daily theatre activities can be considered lifesaving, few are as immediately gratifying as the successful cardiopulmonary resuscitation. CPR is one of the first skills taught to us in medical school and is the one of the core competencies required of the medical graduate. As we become independent practitioners, it is often a requirement to be ACLS (Advanced Cardiac Life Support) certified. Our ability to carry out advanced resuscitation is tested at both Diploma and Fellowship exit examinations, with a focus on the anaesthesia provider taking on a leadership role. While this is a “clinical drill” that the anaesthesia trainee should be familiar with, we do not undertake formal training in this subject.

The purpose of this booklet is to identify causes contributing toward the deficiencies in preparedness for the on table cardiac arrest scenario, suggest methods by which this can be improved and describe the latest updates and key changes to ACLS management. An approach to managing cardiac arrest in specialised perioperative scenarios like the proned patient and the term parturient will also be addressed.

PERIOPERATIVE CARDIAC ARRESTS

When looking specifically at anaesthesia related cardiac arrest the reported incidence has been limited to region specific data. A 2015 report from the US National Anaesthesia Outcomes Registry revealed the incidence of anaesthesia related cardiac arrest to be 5.6 per 10 000 (951 in almost 1.7 million cases).

A 2014 University of Nebraska Medical Centre systematic database review sought to categorise their perioperative arrests (cardiac arrest with 24 hours of the operation/ anaesthetic) into “anaesthesia-attributable” in which direct links to the anaesthetic treatment were identified, and “anaesthesia-contributing” where other perioperative factors played more of a role in the cause of arrest. Based on this classification, they determined an incidence of 0.6 per 10 000 anaesthetics for the former category and 1.1 per 10 000 for the latter.[1]

On the African continent, a prospective audit done by the Lagos University teaching hospital in 2013, determined the incidence of perioperative cardiac arrest to be 9 in 4229 cases or 22.28 in 10 000. [2]

In the 2018 ASOS study by Biccard et al, data on anaesthesia related cardiac arrest was not specifically collected. However, in discussion with the author, the mortality rate within the first 24 hours could be extrapolated to give us a ‘Day of Surgery’ cardiac arrest rate of 11 per 10 000.[3] In the absence of dedicated data collection for in-theatre cardiac arrests (iTCA), it is difficult to precisely quantify its prevalence in our setting. An easily attainable metric, such a as a departmental survey of staff experiences, may be more telling. One can conclude, however, that iTCA are frequent enough to warrant a slick and practised response from anaesthetists.

The ACLS guidelines were developed by the AHA as a progression from basic life support that could be taught to emergency personnel and clinicians to improve the survival of patients having OHCA (Out of Hospital Cardiac Arrests).

The growth and success of the training programme allowed its adaptation and adoption to the IHCA (In hospital Cardiac Arrest) scenario. In OHCA, it is envisioned that the most prevalent cause of cardiac arrest will be cardiac ischaemic events or arrhythmias. For this reason, the focus of BLS and ACLS protocols lie with adequate chest compressions and early defibrillation and pharmacotherapy aimed at reversing the above. [4]

The intra-operative setting differs from the OHCA scenarios in a few important ways.

- It is always a witnessed arrest resulting in a more rapid response than is necessarily seen elsewhere.
- Events prior to the arrest are known. ECG monitoring already on patient. Can be a situation that deteriorates over minutes to hours which is being managed with various inotropes and vasopressors.
- Patient's pre-arrest medical comorbidities are usually known to the anaesthetist as well as any accompanying baseline investigation results.
- The causes and contributions to cardiac arrest are of a different composition intra-operatively compared to other settings both in OHCA and IHCA.
- Greater availability of ultrasound to do point of care testing compared to other in-hospital settings like the general ward.
- As the ethical implications of resuscitation are being reviewed in recent times, the intra-operative cardiac arrest situation may be ideally informed regarding patient's advanced directives and make them more able to incorporate the shared decision-making process to decide on the degree of escalation of care.[5]

While the theatre environment does have advantages for the timeous diagnosis and treatment of cardiac arrest, in other regards it is a hindrance. The extensive draping of the patient and positions like proning, and the beach chair can limit access to perform auscultation, ultrasound examination of the chest or to gain additional IV access without first returning the patient to supine position. Another important disadvantage can be the presence of an open surgical field of a procedure still in progress. The fate of the surgical procedure becomes a further consideration to the post-resuscitation care that does not occur in other scenarios.

The ACLS protocol for adult resuscitation calls on the rescuer to consider the "Hs and Ts" as a quick form checklist of the possible reversible causes of cardiac arrest. In the operating room, however, there are quite a range of causes to consider that are specific to the environment. [5]

- Vagal responses to surgical stimulation may result in symptomatic bradycardias and arrest
- The use of sympatholytic drugs and the inhibition of T1 to T4 cardiac accelerator fibres through high spinal blockade are commonplace in anaesthetic practise.
- Hypoxia, while an unlikely cause in the OHCA setting, is much more common in peri-induction cardiac arrests.
- The haemorrhaging trauma patient is more likely to go into PEA
- Drug interactions, toxicities and anaphylaxis and transfusion reactions should be foremost in the considerations to exclude in theatre

- Inhalational and IV anaesthetic overdose, local anaesthetic systemic toxicity, malignant hyperthermia, severe bronchospasm, and the development of auto-PEEP
- In specific surgeries, cause may be related to the conduct of surgery. E.g., in ophthalmic surgery the oculo-cardiac reflex can potentially deteriorate into cardiac arrest or the formation of venous air embolism in neurosurgical procedures. In orthopaedic surgery, bone cement implantation syndrome is a common cause of asystolic arrest.
- Hypothermia is unlikely to occur unnoticed in a non-cardiac theatre but during cardiac surgery, hypothermia induced during cardiopulmonary bypass that is insufficiently reversed is often a contribution to shock refractory arrhythmia.
- Tension pneumothorax is of greater concern following invasive procedures like insertion of a CVC, supraclavicular nerve blocks, paravertebral blocks, or open tracheostomy. It may also become apparent due to the use of positive pressure ventilation in a patient with bullous lung disease, or an undiagnosed small volume pneumothorax.

Moitra and colleagues suggest that the widely adopted ACLS protocolised approach to cardiac arrest is insufficient for the on-table cardiac arrest situation and proposed alternative protocols to be implemented for cardiac arrest, bradycardia, and tachycardia. [5] This raises the question of whether the operating room cardiac arrest warrants its own protocol and what should be considered the standard of practise. This would undoubtedly have implications for medico-legal disputes as well as peer-review and clinical governance procedures.

LESSONS FROM AVIATION AND SIMULATION TRAINING

Anaesthesia has long borrowed and adapted concepts from aviation to apply to the way we prepare our own trainees. As for pilots, anaesthesia providers must work under conditions of high mental workload, combined with accurate performance of physical skills while being always situationally aware. The failure to perform these tasks adequately in either scenario can result in the loss of life.

An example of a success in disaster avoidance that is much cited in many a treatise on emergency management (by anaesthetists) is the 2009 “miracle on the Hudson” safe water landing of Flight 1549 by Capt Chesley Sullenberger and First officer Jeff Skiles. Their success has been attributed in different writings to the application of experience and expertise in some and the appropriate use of an emergency checklist in others.

When an emergency occurs in aviation, pilots are trained to quickly identify the warning and then follow a set of pre-ordered tasks in the completion of a “troubleshoot” checklist. These often consist of a set of immediate actions, often denoted by a “memory box”, which are essential to prevent the immediate loss of the aircraft. These actions, as the name suggests, need to be performed from memory. Depending on the airline they work for, type of aircraft they fly or the regulatory authority they work under, commercial pilots may be required to undergo repeat training at 6-, 9- or 12-month intervals.

F900EX Airplane Flight Manual	EMERGENCY PROCEDURES FIRE AND SMOKE Engine fire or obvious engine damage	2-050-05 PAGE 1 / 2 Issue 1

FIRE .. - ENGINE FIRE

FIRE .. light on.
Aural warning sounds.

> **NOTE**
>
> The following procedure must be applied, whether or not the FAULT light is on.

▶ PHASE 1

- Power lever of engine concerned .... Cut-off
- FUEL SHUT OFF switch of engine concerned .... Actuated
- Airspeed .... Below 250 KIAS
- Fire extinguisher DISCH .... Position 1
- **If fire warning persists:**
  - Fire extinguisher DISCH .... Position 2

▶ PHASE 2

- TRANS light .... On then off
- Engine shutdown .... See 3-100-10
- **If engine 2 shutdown:**
  - A - B busses .... Tied
  - ST-BY PUMP .... As required
- Land as soon as possible.

Example of a Checklist for and Engine Fire Warning with the "memory box" items appearing in the red.

2020Nov, Immediate Action!

http://code7700.com/immediate_action.htm

All things aviation for professional aviators

Dr Goldhaber et al of Stanford University Dept. of Anaesthesiology put forth a case for the use of "Emergency Manuals" or "bundle of cognitive aids relevant for a particular context such as perioperative care". Cognitive aids are tools designed to assist practitioners to access and apply information at the time of crisis that they often are already familiar with. The motivation to use these aids lies in the fact that practitioners often have trouble recalling information that they rarely have the need to access.

In examining the psychology behind how humans respond to complex emergency situations, research psychologist, Gary Klein, developed the concept of the Recognition Primed Decision-making model in which the person intuitively identifies a familiar pattern that is present in the situation at hand. They then assess how well it fits through the routine of mental simulation exercise to "imagine" how the action they may take will play out in this scenario. Experts are more adept at this process and are more likely to correctly identify the pattern compared with less experienced individuals.[6] This process however is susceptible to biases and error. Stressful situations impair memory functions like accessing "archived information", making calculations e.g., drug dosages in your mind and even short-term memory recall such as reminding yourself to complete a task in the near future, also known as prospective memory.
For these reasons, Stanford Dept. of Anaesthesiology developed and implemented their perioperative specific Emergency Manuals which are freely downloadable at this website. http://web.stanford.edu/dept/anesthesia/em/semv3.1.pdf

A counter argument to this approach would be, that where emergency checklists or manuals can aid the clinician, it can also be a hindrance. An incorrect initial diagnosis can lead to the "wrong" checklist being used and time wastage or worse, patient harm. "Fixation errors occur when the practitioner concentrates solely upon a single aspect of a case to the detriment of other more relevant aspects"[7]. An example would be, operator fixation on tracheal intubation in the 'Can't intubate, can't oxygenate' scenario in which the patient is now peri-arrest.

McEvoy's 2010 Annual Meeting of the American Society of Anaesthesiologists presentation on the use of cognitive aids effect on retention of skill in the management of cardiac arrests had two important conclusions:

"First, there is a significant loss of skill in ACLS management only 6 months following training. Second, use of cognitive aids improves performance at 6-month follow-up to levels comparable to initial post-test."

"Emergency Manuals" or check lists continue to have their supporters and detractors in the field of perioperative medicine. If, however, one is to rely solely on previously gained knowledge and experience, the dilemma arises as to where such experience must needs come from and which patients should suffer for that educational process.

Institutions are advised to undertake an internal audit process to assess the role of cognitive aids within their protocols. It is important to note that their successful implementation is contingent on the quality of training staff receive in their use.

Why simulation works?

The on table cardiac arrest emergency is one not commonly encountered in daily anaesthetic practise, yet when it arises, the provider must seamlessly and without delay address and manage the problem and do so in a leadership role. Failure to act timeously and correctly results in the loss of the patient.

The ideal candidate to deal with this scenario would be an artificial intelligence robot or similar device which is immune to blaring alarms, surges of catecholamines giving flight or fight responses, shaking hands, memory lapses, panic, and anxiety. In the absence of existence of this perfect being, the anaesthetic provider needs to strive to be quick thinking, cool and calm under immense pressure.

The AHA has a well-developed, prescribed method for training ACLS providers that combines theory and simulation training. This method is used around the world to ensure rescuers have the most up to date knowledge. ACLS certification needs to be repeated at 2-year intervals to remain valid. This can often involve repeat BLS certification as an initial step.

De Lago published a study in 2020 examining the knowledge levels of clinicians in anaesthesia regarding the 2015 advanced life support resuscitation guidelines at 3 academic hospitals in Johannesburg. Out of 168 participants, it was found that only 7.1% had adequate knowledge (deemed to be 80% score on the research questionnaire).

In the same local study mentioned above, De Lago found that of the 168 participants surveyed: "BLS, ACLS and PALS courses were completed by 136, 116 and 70 participants respectively. Of the participants who had completed these courses, 28.4%, 20.7%, 11.2% were current in their certification in the respective courses." Barriers to maintaining 'up to date' certification include the cost involved, which is not always subsidised by the employer, time required away from regular clinical duties to attend, and prevailing attitudes that current knowledge is sufficient. To assess your current knowledge level of the ACLS algorithm you can visit https://www.acls.net/quiz.htm

Simulation training with or without the use of high-fidelity manakins has been shown to improve the efficacy of cardiopulmonary resuscitation efforts. By undergoing repetitive training in these “drills”, it is thought that the provider can be desensitised to the anxiety that arises from emergencies

ACLS UPDATES

Advanced Cardiac Life Support was developed formally in 1979 and the first algorithms appearing in literature in 1986. [4] These guidelines were updated every 5 years until 2015 when the updates became a continuous process.

Some of the highlights of the previous updates are contained in the table below. [8-10]

Year	Highlighted change
2005	• Universal compression to breath ratio of 30:2 for all single rescuers – A Change from the 15:2 previously recommended. • Advocated therapeutic hypothermia in the post-resuscitation phase. • Reduction in interruptions to high-quality CPR by changing from 3 stacked shocks to 1 followed by immediate CPR.
2010	• Change from *A B C* to *C A B.* – Based on the understanding that in adults, in whom the cause of cardiac arrest was VF or pulseless VT, best outcome was with immediate compressions and early defibrillation. • Advocated the use of AEDs as part of activating an emergency protocol. • Training focused on adequacy of chest compressions in rate and depth. Depth stipulated at 1.5 to 2 inches. • Atropine removed from treatment of pulseless electrical activity/ asystole • Recommended the use of PEtCO2 to monitor CPR quality and detect ROSC • Added specific Post-Cardiac Arrest care algorithm • Specific guidelines on the management of ACS and Stroke, • Paeds: pulse assessment is deemphasized for healthcare providers • Cuffed endotracheal tubes advocated. Cricoid pressure necessity questioned • initial energy dose of 2 to 4 J/kg of either waveform is reasonable; doses higher than 4 J/kg, especially if delivered with a biphasic defibrillator, may also be safe and effective. • ABC retained for neonatal resuscitation. 3:1 Chest compression ratio. Adrenaline 0.01 to 0.03 mg/kg dose per bolus. [8]
2015	• Upper limit to compression rate of 120 beats per minute. Upper limit to chest compressions to 2.4 inches to avoid injury. • In patients with a definitive airway, the rate of ventilation now becomes 1 per every 6 seconds with continuous compressions. • New technologies explored included impedance threshold devices to judge efficacy of CPR, mechanical compression devices, extracorporeal CPR • Support use of the maximal feasible oxygen delivery during CPR. • Epinephrine use advised to be 1 mg every 3 – 5 mins • Vasopressin removed from ACLS algorithm • Steroids were under consideration as part of a bundle of IHCA care • Use of PEtCO2 as a prognosticator for outcome after CPR

	• Post-arrest care: Early angiography and coronary intervention is recommended in both ST segment elevation and non-ST elevation when an acute coronary event is suspected regardless of neurological status as these are difficult to interpret acutely. • Targeted temperature management is advised in patient with persistent coma post ROSC. However, the target is anywhere between 32 and 36 degrees Celsius. for at least 24 hours after achieving target temperature. • Neurological status should be assessed for prognostication at least 72 hours after ROSC where no TTM has been used, and 72 hours after return to normothermia where TTM was used. • Maintained the stance that in obstetric patients where the height of Fundus is greater than level of the umbilicus, manual leftward displacement of the uterus is advised. • Peri-mortem caesarean section advised at 4 – 5 minutes post onset of maternal cardiac arrest/ resuscitative efforts without ROSC • PAEDS: C A B maintained for lack of better evidence. Compression depth recommended is 1/3 the antero-posterior diameter. Compression only CPR insufficient and associated with worse outcomes in paediatric cardiac arrest situations. Strict maintenance of normothermia is as effective as 2 days of hypothermia in patients comatose after OHCA. • "The use of high-fidelity manikins for ALS training can be beneficial in programs that have the infrastructure, trained personnel, and resources to maintain the program. Standard manikins continue to be an appropriate choice for organizations that do not have this capacity."[9]
2020	• Reaffirming the need for high quality chest compressions in rate and depth. • Double Sequential Fibrillation: Resuscitation teams may consider this strategy for shock-refractory episodes of ventricular fibrillation. (weak evidence). • Intraosseous Access: Teams should first attempt IV access before moving to intraosseous route. • Epinephrine in cardiac arrest: resuscitation teams should continue to administer epinephrine for the treatment of cardiac arrest in adult patients at 3–5-minute intervals for the duration of the resuscitation attempt. • Timing of dose: As soon as feasible with non-shockable rhythm. Changes to the algorithm now depict epinephrine administration as appropriate after the second defibrillation attempt for shock refractory rhythms. • CPR in the pregnant patient with HOF above umbilicus – compressions should be performed in supine position with left uterine displacement. Prepare for caesarean section to be performed within 5 minutes of cardiac arrest with appropriate personnel. • Recommend against the use of POC ultrasound for prognostication in cardiac arrest. • Post-resuscitation care broken down into phases: Stabilisation, Additional emergency activities after ROSC, key considerations like Blood pressure management, treatment of seizures and targeted temperature management. • Improved methods of Neuroprognostication in patients who remain comatose after cardiac arrest. At least 72 hours post ROSC to avoid confounding effects of medication, return of normothermia etc. • Recovery and survivorship newly described: Address rehabilitation, surveillance, to treat the sequelae physiologic and psychologic of cardiac arrest. [10]

CARDIOPULMONARY RESUSCITATION IN SPECIAL SCENARIOS

1. The Pregnant Patient at Term

a. Team planning for cardiac arrest in pregnancy should be done in collaboration with the obstetric, neonatal, emergency, anaesthesiology, intensive care, and cardiac arrest services
b. Priorities for treating the pregnant woman in cardiac arrest should include provision of high-quality CPR and relief of aortocaval compression through left lateral uterine displacement'
c. If the pregnant woman with a fundus height at or above the umbilicus has not obtained ROSC with usual resuscitation measures plus manual left lateral uterine displacement, it is advisable to prepare to evacuate the uterus while resuscitation continues
d. To accomplish delivery early, ideally within <u>5 minutes</u> after the time of arrest, it is reasonable to immediately prepare for perimortem caesarean delivery while initial Basic Life Support (BLS) and Advanced Cardiovascular Life Support (ACLS) interventions are being performed (Class 2a, LOE C-EO), although provider skill set and available personnel and resources may also logically influence this timing[10]
e. CPR modifications
   - wedge to give left lateral tilt (pillow or knees of chest compression person)
   - hand slightly higher on sternum for chest compressions
   - slightly quicker compressions
   - early intubation
   - remove CTG prior to defibrillation
   - quickly prepare for perimortem C/S (within <u>4 min</u>) -> save baby and helps mum by relieving aortocaval compression (no need if baby < 20 weeks).[11]

2. Prone positioned patient

a. 2010 AHA update to ACLS recommended returning patient to supine position to initiate CPR. 2020 update recommends either returning the patient to the supine position or initiating CPR in the prone position. (Influenced by the COVID 19 pandemic)
b. Returning proned patient to the supine position in the Cardiac Arrest scenario can take as many as 5 – 6 people and up to 3 minutes. A 2020 update of basic and advanced CPR recommendations for the COVID-19 pandemic recommends either returning the patient to the supine position or initiating CPR in the prone position
c. A 2017 study reviewed CT thoracic images to locate the optimal hand position for compressions performed in the prone position and concluded that T7–T9 (Between the shoulders) was the most effective location because it aligned with the place where cardiac section is the widest. [12]
d. Effectiveness of advanced life support in the prone position depends on pre-existence of secured airway and IV access.
e. Chest compressions can be more strenuous in the prone position due to stiffness of the costo-vertebral joints. Relies on a hard surface to be placed under patient's sternum.

f. In patients with a midline surgical incision such as for posterior lumbar fusion, prone chest compression with 1 hand on each side of the incision has been successfully used.
g. Placement of adhesive defibrillator pads can both armpits OR one in the left axillary midline and the other at the level of the tight scapula.

3. Neurosurgical patients

Often present a challenge with unconventional positioning, extensive draping reducing access to the patient. Additionally, the surgical stimulation can produce a variety of deleterious haemodynamic effects.

- The trigeminocardiac reflex which occurs in supratentorial surgery can be responsible for a bradycardic, hypotensive response which in some cases may be refractory to atropine and may require adrenaline boluses in addition to removal of the stimulus.
- It is also a commonly stimulated reflex in skull base surgery like transsphenoidal pituitary resection and microvascular decompression for the treatment of Trigeminal Neuralgia.
- Increased parasympathetic outflow from certain procedures like insular cortical, amygdaloid complex and limbic stimulation for epilepsy surgery can result in bradycardias and sometimes asystole.
- Intracranial hyper and hypotension are both causes for haemodynamic disturbances such as may occur during evacuation of intracranial haematomas, insertion of VP shunts, EVDs and subgaleal suction.
- In posterior fossa surgery, venous air embolism is an important consideration with paradoxical embolism to the coronary arteries being the purported pathophysiology of cardiac arrest.
- Sudden asystole has been reported during cerebello-pontine angle tumour resection.
- Glossopharyngeal-vagal reflex is also implicated in bradycardia and hypotension via efferents to the carotid sinus.
- Myocardial ischaemia can result from cerebrovascular interventions in which coronary vasospasm occurs during aneurysm clipping.
- Spines: Venous air embolism, autonomic dysreflexia, bleeding especially in cervical and upper thoracic surgeries.
- Skull pin fixation poses a unique risk to the C-Spine during CPR and defibrillation as the uncontrolled movement of the patient’s body may result in injury. Additionally, a recovering patient may cough or gag resulting in similar traction injuries to the cervical spine. Recommendations often include taking the patient off skull fixation prior to defibrillation. NMB can avoid the potential risks of a coughing patient.
- Prone positioning and the approach to CPR in this scenario has been discussed above. In the case of the open spine, it is advisable for the sterile field to be maintained by the neurosurgeon performing the compressions initially while the anaesthetist handles drugs and ventilation management.
- Venous Air Embolism should be managed with FiO2 of 1.0, Fluid administration, vasopressors and attempts at aspiration of air from the RA through an appropriately sited CVC. CPR theoretically helps to break up “air locks” that are responsible for cardiovascular collapse. Surgeon may also flood the surgical field with saline to stop the entrainment of air. [13]

COVID positive patient

The following guidelines are quoted from the resuscitation council of South Africa:
Regarding CPR in the Confirmed COVID-19 Positive In-patient:

- Cardiac Arrest due to progression of the disease process itself is unlikely to be reversible and CPR is not considered to be beneficial.
- Should there be an immediately reversible cause, like a blocked ETT, accidental extubation or arrhythmia a short period of CPR may be indicated provided the cause may be reversed. This should be undertaken with adequate safety provisions for the healthcare worker. Appropriate PPE should be worn for the 2 main components which are Airway control and compressions.
- The institution is advised to develop protocols and policies specific to the resources available to them.
- The guideline statement makes reference to the Arizona protocol for resuscitation in a non-intubated patient in which a tightly fitting 100% non-rebreather facemask is placed on the patient's face while compressions are undertaken continuously for 2 minutes followed by a pulse check and then followed with 6 minutes of continuous compressions. If no ROSC has been achieved in this time or no reversible cause has been identified, then it is reasonable to stop CPR efforts.

POST-RESUSCITATION CARE

The post-resuscitation care of the patient who has suffered a cardiac arrest is a discreet topic on its own and as such, cannot be covered completely within the scope of this talk. I will introduce the broad headings of management and the latest guideline recommendation on each.

From the AHA 2020 update executive summary.

The initial objectives of post–cardiac arrest care are to:
• Optimize cardiopulmonary function and vital organ perfusion.
• After out-of-hospital cardiac arrest, transport patient to an appropriate hospital with a comprehensive post–cardiac arrest treatment system of care that includes acute coronary interventions, neurological care, goal-directed critical care, and hypothermia.
• Transport the in-hospital post–cardiac arrest patient to an appropriate critical-care unit capable of providing comprehensive post–cardiac arrest care.
• Try to identify and treat the precipitating causes of the arrest and prevent recurrent arrest.
Subsequent objectives of post–cardiac arrest care are to:
• Control body temperature to optimize survival and neurological recovery o TTM 32 -36˚C x 24 hours
• Identify and treat acute coronary syndromes (ACS)
• Optimize mechanical ventilation to minimize lung injury.
o PACo2 and EtCO2 targets are 40 - 45mmHg and 35 – 40mmHg respectively
o titrate inspired oxygen to the lowest level required to achieve an arterial oxygen saturation of ≥92 - 98%
o Maintain systolic BP >90mmHg and/ or MAP > 65mmHg
• Reduce the risk of multiorgan injury and support organ function if required
• Objectively assess prognosis for recovery
o Neuroprognostication should not be made within 48 to 72 hours post arrest and taking into account the patient's temperature in this time. Longer period needs to be taken in the cooled patient. An M score </= 3 at >/= 72 hours is a poor prognostic sign.
o Biomarkers NSE (Neuron specific Enolase) >60mcg/L
• Assist survivors with rehabilitation services when required[14]

Targeted Temperature Management

- According to the 2020 consensus update from the European Resuscitation Council, TTM is recommended for all adults post either OHCA or IHCA with *any* initial rhythm who remain unresponsive after ROSC.
- 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, but to no higher than 36 °C.
- Maintain a constant temperature between 32°C and 36°C for at least 24 hours.
- Avoid Fever > 37.7°C for a minimum of 72 hours post ROSC in patients who remain in a coma.
- Maintain normoxia and normocapnia and euglycaemia

Steroids

- According to ILCOR evidence update guidelines of 2020 states that there is not enough evidence to support the routine administration of steroids in the immediate post-ROSC phase.

Haemodynamic

- Avoid hypotension MAP < 65mmHg. Target a urine output of 0.5ml/kg/hr and a normal or decreasing lactate value.
- Use vasopressors judiciously. No one vasopressor has shown mortality benefit over another. Noradrenaline was the pressor most commonly in use in the institutions studied for this update.

Seizures

- Routine administration of seizure prophylaxis is not recommended. Treatment of seizures should be undertaken with Sodium Valproate or Levetiracetam. [15]

Once patient has been placed in ICU

- Use short acting sedatives and opioids.
- Stress ulcer prophylaxis is still recommended.
- VTE prophylaxis
- Control blood glucose within a range of 7.8 – 10mmol. Use of insulin infusion as necessary.
- Enteral feeds may be commenced during TTM.
- If the chosen temp is at 36° then gastric feeds may be given early.
- No place for antibiotic prophylaxis routinely.

Management of Awareness and Pain during CPR

The improvement in quality of chest compressions during CPR has resulted in more case reports of patients retaining higher neurological function during cardiac arrest. There is concern that this has lead to neurocognitive adverse outcomes like post-traumatic stress disorder on a similar spectrum to awareness under anaesthesia. AWARE: A prospective study by Parnia et al in 2014 reported on the incidence of perceptions, awareness, memory formation and other recollections which fall under the Greyson Near Death Experience Scale. The study found that up to 39% of the 140 survivors reported "remembering" events during their unconsciousness. Other case reports included descriptions of patients having spontaneous eye opening, purposeful movement or verbal responses during cardiac compressions. [16]

A Nebraska protocol for sedation/ pain management during CPR includes the administration of Ketamine (0.5 – 1mg/kg IV OR 2 – 3mg/kg IM) with the option of adding Midazolam bolus 1mg IV. [17] However, Samaniego et al concluded that the use of sedation in the post-ROSC period in which temperature management was employed was confounding the assessment of the patient's level of consciousness. [18]

While the latest ACLS updates do not address this in their protocol, a 2017 Australian study by Olaussen found an improved survival correlation in patients who displayed CPR induced consciousness and did not discover any influence on survival in patients who received midazolam or opiates. [19] Given that on table cardiac arrest algorithms usually call for volatile anaesthetics to be discontinued/ flushed out as part of initial response, perhaps consideration should be given to the provision of analgo-sedation during CPR.

CONCLUSION

Cardiac arrest in the non-cardiac theatre occurs with sufficient frequency to warrant an immediate, practised response. The theatre environment provides a unique set of circumstances which work to simultaneously aid and hinder the rescuer. There is a knowledge gap regarding local contributing factors and outcomes of in-theatre arrests. Many factors contribute to a decay in skill of the perioperative team in both recognition of the crisis and its management.

Better systems need to be put in place to ensure adequate training of the anaesthesia provider to manage the cardiac arrest scenario in a leadership role as well ensure that they regularly update their certification. Certain scenarios are theatre specific and require a tailored approach to provision of resuscitation. While the ACLS protocol may not be the ideal fit for the in-theatre patient, it remains to be seen if theatre specific protocols will significantly improve outcomes.

The provision of so-called “emergency manuals” is an interesting prospect for quality improvement processes. Lessons can be learned from the aviation industry in safety culture and ongoing simulation training as well as the incident reporting process. The creation of a perioperative cardiac arrest registry may significantly improve our understanding of this topic.

> *"Everything we know in aviation, every rule in the rule book, every procedure we have, we know because someone somewhere died... We have purchased at great cost, lessons literally bought with blood that we have to preserve as institutional knowledge and pass on to succeeding generations. We cannot have the moral failure of forgetting these lessons and we have to relearn them.*"
>
> - Captain Chesley “Sully” Sullenberger [20]

REFERENCES

1. Ellis, S.J., et al., *Anesthesia-related Cardiac Arrest.* Anesthesiology, 2014. **120**(4): p. 829-838.
2. Adekola, O.O., et al., *The outcome of anaesthesia related cardiac arrest in a Sub-Saharan tertiary hospital.* Egyptian Journal of Anaesthesia, 2016. **32**(3): p. 315-321.
3. Biccard, B.M., et al., *Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study.* Lancet, 2018. **391**(10130): p. 1589–1598.
4. *The History of ACLS Certification by American Heart Association - ACLS EDU*. 2020.
5. Moitra, V.K., et al., *Cardiac Arrest in the Operating Room: Resuscitation and Management for the Anesthesiologist: Part 1.* Anesth Analg, 2018. **126**(3): p. 876-888.
6. Klein, G., *A naturalistic decision making perspective on studying intuitive decision making.* Journal of Applied Research in Memory and Cognition, 2015. **4**(3): p. 164-168.
7. Fioratou, E., R. Flin, and R. Glavin, *No simple fix for fixation errors: cognitive processes and their clinical applications.* Anaesthesia, 2010. **65**(1): p. 61-9.
8. Field, J.M., et al., *Part 1: Executive Summary.* Circulation, 2010. **122**(18_suppl_3): p. S640-S656.
9. Neumar, R.W., et al., *Part 1: Executive Summary.* Circulation, 2015. **132**(18_suppl_2): p. S315-S367.
10. Merchant, R.M., et al., *Part 1: Executive Summary: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.* Circulation, 2020. **142**(16_suppl_2): p. S337-S357.
11. *CPR and Pregnancy • LITFL • CCC Obstetrics*. 2020.
12. Anez, C., et al., *Cardiopulmonary Resuscitation in the Prone Position in the Operating Room or in the Intensive Care Unit: A Systematic Review.* Anesthesia & Analgesia, 2021. **132**(2): p. 285-292.
13. Chowdhury, T., A. Petropolis, and R.B. Cappellani, *Cardiac Emergencies in Neurosurgical Patients.* BioMed Research International, 2015. **2015**: p. 751320.
14. Peberdy, M.A., et al., *Part 9: Post–Cardiac Arrest Care.* Circulation, 2010. **122**(18_suppl_3): p. S768-S786.
15. Arafeh, J., et al., *Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.* Circulation, 2020.
16. Parnia, S., et al., *AWARE-AWAreness during REsuscitation-a prospective study.* Resuscitation, 2014. **85**.
17. Rice, D.T., et al., *CPR induced consciousness: It's time for sedation protocols for this growing population.* Resuscitation, 2016. **103**: p. e15-e16.
18. Samaniego, E.A., et al., *Sedation confounds outcome prediction in cardiac arrest survivors treated with hypothermia.* Neurocritical care, 2011. **15**(1): p. 113-119.
19. *BestBets: Pain management in patients who show awareness during CPR*. 2021.
20. Syed, M., *Black Box Thinking: The Surprising Truth About Success*. 2015, London, United Kingdom: John Murray Press. 352.