Cardiopulmonary Resuscitation in the Neurosurgical Patient under Anesthesia

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Abstract

Cardiac arrest inside the neurosurgical theatre is a grave crisis which can end up in a remarkably high mortality rate. It is an uninvited crisis to both the neurosurgeon and the neuroanesthetist. It has numerous causes and can happen during different kinds of surgeries along with positions. Management of cardiac arrests in neurosurgical patient population is a territory that is not well elucidated. Conventional ALS protocols cannot be straightaway applied in neurosurgical patients at all times. With a good comprehension, practitioners can be better geared up to tackle unfavourable cardiac emergencies which can be gruelling to the whole neurosurgical team.

Keywords: Cardiac arrests, emergencies, intraoperative cardiac arrest neurosurgery, intraoperative cardiac emergencies, neuroanesthesia

Introduction

Cardiac arrest in non-cardiac surgery occurs with a documented incidence of 0.01–0.34%.[1-3] As per a Japanese research, the major origins of intraoperative cardiac arrest comprise of blood loss (31.9%), human errors (53%) and anesthesia associated (22%).[4] The management of intraoperative cardiac arrest during neurosurgery has not been well defined since they are quite uncommon. Application of conventional resuscitation manoeuvres could be challenging because of various factors like surgical patient positioning and exposure, skull pin fixation, etc. This article focusses on outlining the different reasons of cardiac arrest during neurosurgery, and their management as per the scenario.

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CARDIO PULMONARY RESUSCITATION (CPR) DURING NEUROSURGERY

Common causes of intraoperative cardiac arrest during neurosurgery are given in Table 1.

Table 1: Common causes of perioperative cardiac emergencies during neurosurgery

Common causes of cardiac emergencies during neurosurgical procedures
Trigemino-cardiac reflex
Surgical manipulation of structures like insular cortex, amygdala, brainstem, hypothalamus, floor of fourth ventricle, cranial nerves
Venous air embolism
Acute blood loss
Sudden increase in intracranial pressure (ICP) o Anesthetic factors- hypercarbia, hypoxia o Surgical factors- bleeding, seizures, aneurysm rupture
Irrigation with extreme warm or cold saline
Anaphylaxis
H's [hypovolemia, hypoxia, hydrogen ion (acidosis), hyper-/hypokalemia, hypoglycemia, hypothermia] and, T's [toxins, tamponade, tension pneumothorax, thromboembolism, trauma]

In general most of the subjects will be already on mechanical ventilation with end-tidal carbon dioxide (EtCO2) monitoring and an invasive arterial line in situ. Both these monitors provide added advantage as they can be utilised to confirm the cardiac arrest, act as a guide to the quality of CPR and indicate the return of spontaneous circulation (ROSC).5

As soon as cardiac arrest is diagnosed, resuscitation should be initiated and simultaneously ensure the following:

1.Ventilation is maintained:
a.Rule out endotracheal tube obstruction , kinking, displacement or disconnection
b.Provide 100% oxygen
2.All drugs have been given correctly
3.There has not been a sudden rapid massive blood loss

Management of cardiac arrest can be guided by the proposed algorithm (Figure 1), aided by the latest Advanced Life Support (ALS) guidelines given by the American Heart Association (AHA) [5]. As per the United Kingdom (UK) resuscitation council 2019, the sole difference from the ALS guidelines is that the starting dose of epinephrine should be given in increments (e.g. 50–100 micrograms) as per the response, instead of a 1 mg bolus.6 It will help to prevent any rebound rise in blood pressure and possibility of hemorrhage if resuscitation is successful in a short time span. In case of no response even after 1 mg total of epinephrine, administer the next doses of epinephrine 1 mg boluses as per the usual ALS protocol. Identification and treatment of the underlying cause should be carried out simultaneously.

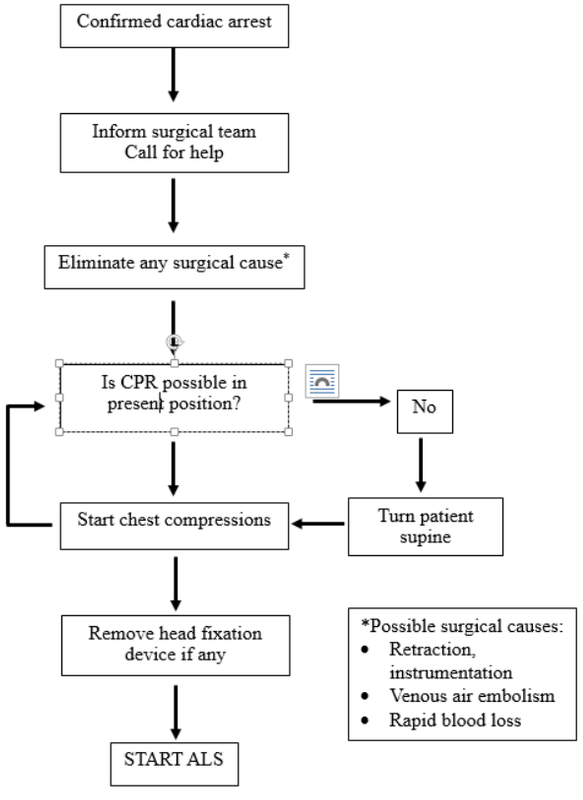

Figure 1. Cardiac arrest in neurosurgery algorithm

PECULIAR ELEMENTS AFFECTING INTRAOPERATIVE CPR DURING NEUROSURGY

These can be classified as:

1.The surgical procedure.
2.The position of the patient.
3.CPR on a patient with an exposed wound.

1.The surgical procedure

Surgeries around the hypothalamus, brain stem, cerebellopontine angle, hypophysis, and fifth cranial nerve, neuro-endoscopic procedures and the use of irrigation fluid of the incorrect temperature or pressure, can all lead to heart rate irregularities including severe bradycardia with associated hypotension or asystole. The most probable mechanism behind is stimulation of the trigemino-cardiac reflex. Usually this will revert on stopping of the stimulus (e.g. surgical instrumentation or traction). If the bradycardia persists, give atropine, epinephrine infusion or transcutaneous pacing as per the AHA ALS guidelines.[5]

Usually pre-emptive use of anticholinergics are avoided as it might result in the loss of the indication of surgical encroachment on vital areas.

If the patient develops asystole, commence CPR as soon as possible.

2.The position of the patient (table 2)

a.Supine position

Here the concern is that any effort to carry out chest compressions with the head of the patient attached to the head fixation device (Mayfield or Sugita) may cause damage to the scalp, skull and cervical spine. This may also happen due to involuntary movement due to defibrillation. Hence it is reasonable that the head of the patient should be detached from the fixation device before giving shock or chest compressions as soon as feasible.

There also lies a possibility of defibrillation resulting in burn injuries at the site of insertion of the skull pins. However, no documentation is made in literature of any evident damage due to burns at the point of pin entry.[7,8]

Start CPR in the time the neurosurgeon holds the patient's head. Later on move the patient down the operation table so that a fixed rest is provided for the head.

b.Lateral position

Despite the fact that carrying out chest compressions with the patient in lateral position has been documented, its effectiveness is not known.[9] Hence, the patient should be made supine as soon and safely as feasible. If defibrillation is needed, use of the anteroposterior paddle position is suggested; one paddle above the left precordial area and the other just below the left scapula.10 There has also been a case reported in the literature where extracorporeal CPR was used to revive a neurosurgical patient in the lateral position.[11]

c.Prone position

Turning the patient supine is not always immediately possible, due to skull pin fixation, halo fixation, open surgical wounds, or protruding hardware. The time required for recruiting enough hospital personnel to place the patient back in the supine position safely approximately takes around 3 minutes which may cause significant delays in starting CPR.12 There is no immediate need to turn the patient to the supine position; CPR can be started with the patient in the prone position used while preparations

are being made to turn the patient supine. Compressions should be performed in the midline of thoracic spine between T7 and T9 using the same technique as during supine CPR.[13] The 2020 AHA guidelines also recommend that when the victim cannot be placed in the supine position, it may be reasonable for rescuers to provide CPR with the victim in the prone position. In patients with a midline surgical incision, prone chest compression with 1 hand on each side of the incision has been successfully used.[14] In some studies posterior compression generated higher mean arterial pressures than anterior compression.[15,16] The postulated mechanism is that since the abdomen is in contact with a solid surface, the movement of abdominal structures is restricted, making the compressions more effective.[12]

Successful resuscitation following posterior chest compression has been reported.[17-19] As CPR is started, simultaneously remove any surgical instruments from the wound and pack the wound to reduce blood loss. If the patient's head is fixed in pins, they should be managed as described above. Few cases will be made prone with the help of a frame (e.g. Wilson frame, Relton-Hall frame) or pillows and bolsters. In such scenarios chest compression may not be efficacious unless counter pressure from a solid surface is put in. For defibrillation paddles can be kept either posterolateral (one in the left mid-axillary line, the other above the right scapula) or in the bi-axillary positions.[7]

If chest compressions are not effective we should turn the patient into supine position. Attaining this may be tedious, time-consuming and risky because of the presence of an exposed surgical field or an unstable spine.

d.Sitting position

Although there is mostly access to the chest to allow defibrillation or cardiac massage, proper chest compressions are not feasible. Hence the patient needs to be made supine as quickly as possible.

Table 2: Brief of management of cardiac emergencies in various positions

Supine	Immediate chest compressions and/or defibrillation
Prone	Immediate chest compressions: apply compressions between shoulders with fist/support beneath sternum Immediate defibrillation if required Move to supine as soon as possible
Lateral	Begin chest compressions in lateral position: apply chest compressions to sternum while stabilizing back (two-person technique) Immediate defibrillation Move to supine as soon as possible

3.CPR on a patient with an exposed wound

All instruments should be taken out to stop incidental tissue injury. Also following successful resuscitation, achieving hemostasis may be problematic sometimes [20].

POST-RESUSCITATION MANAGEMENT

- ●Quick hemostasis should be secured
- ●Consider further surgical options which may include:
  - oCarry on with the intended original surgical procedure
  - oChange the goals of surgical procedure
  - oAbandon surgery

ADDITIONAL POINTS TO CONSIDER

- Every member of the neurosurgical team (neurosurgeons, neuroanesthetists and surgical staff) should be involved and well trained in the procedure of emergency repositioning of a patient
- Prior to any case ideally we should check and confirm the following:
  - o the resuscitation trolley and defibrillator
  - o a trolley or bed on to which the patient can be laid supine
- In cases with increased chances of an arrhythmia who are not supine or where access is limited, put transcutaneous adhesive defibrillation pads before the start of surgery.
- An accurate documentation of the event and measures taken should be made.
- Review of the event at a local morbidity and mortality meeting or equivalent should be done later on.

CONCLUSIONS

The neurosurgical patient population is unique on whom ALS protocol cannot always be employed conventionally during cardiac arrest, since it is affected by the position, the surgical procedure, and the skull fixation devices used. Therefore it is important to have a good knowledge of underlying causes as well as their management. One should remember that managing such scenarios is always a teamwork involving the neurosurgeons, neuroanesthetists and surgical staff. Resuscitation protocol is individualized as per the scenario and available resources. Training of the concerned operation theatre team including simulation should be done regularly.

References

1. Ellis SJ, Newland MC, Simonson JA, et al. Anesthesia-related cardiac arrest. Anesthesiology. 2014;120(4):829-838. doi:10.1097/ALN.0000000000000153
2. Irita K, Kawashima Y, Iwao Y, et al. Annual mortality and morbidity in operating rooms during 2002 and summary of morbidity and mortality between 1999 and 2002 in Japan: a brief review. Masui. 2004;53(3):320-335
3. Braz LG, Módolo NS, do Nascimento P Jr, et al. Perioperative cardiac arrest: a study of 53,718 anaesthetics over 9 yr from a Brazilian teaching hospital. Br J Anaesth. 2006;96(5):569-575. doi:10.1093/bja/ael065
4. Kawashima Y, Takahashi S, Suzuki M, et al. Anesthesia-related mortality and morbidity over a 5-year period in 2,363,038 patients in Japan. Acta Anaesthesiol Scand. 2003;47(7):809-817. doi:10.1034/j.1399-

6576.2003.00166.x

5. Panchal AR, Bartos JA, Cabañas JG, et al. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020;142(16_suppl_2):S366-S468. doi:10.1161/CIR.0000000000000916
6. Carroll C, Davies R, Gwinnutt C, et al. Management of cardiac arrest during neurosurgery in adults. Resuscitation Council UK publications. 2019. Available at: https://www.resus.org.uk/sites/default/files/2020-05/CPR_in_neurosurgical_patients.pdf. Accessed August 31, 2023.
7. Miranda CC, Newton MC. Successful defibrillation in the prone position. Br J Anaesth. 2001;87(6):937-938. doi:10.1093/bja/87.6.937
8. Moscarelli A, Iozzo P, Ippolito M, et al. Cardiopulmonary resuscitation in prone position: A scoping review. Am J Emerg Med. 2020;38(11):2416-2424. doi:10.1016/j.ajem.2020.08.097
9. Takei T, Nakazawa K, Ishikawa S, Uchida T, Makita K. Cardiac arrest in the left lateral decubitus position and extracorporeal cardiopulmonary resuscitation during neurosurgery: a case report. J Anesth. 2010;24(3):447-451. doi:10.1007/s00540-010-0911-8
10. Bhatnagar V, Jinjil K, Raj P. Complete recovery after cardiopulmonary resuscitation in the lateral decubitus position: A report of two cases. Saudi J Anaesth. 2016;10(3):365-366. doi:10.4103/1658-354X.174921
11. Mullen L, Byrd D. Using simulation training to improve perioperative patient safety. AORN J. 2013;97(4):419-427. doi:10.1016/j.aorn.2013.02.001
12. Anez C, Becerra-Bolaños Á, Vives-Lopez A, Rodríguez-Pérez A. Cardiopulmonary Resuscitation in the Prone Position in the Operating Room or in the Intensive Care Unit: A Systematic Review. Anesth Analg. 2021;132(2):285-292. doi:10.1213/ANE.0000000000005289
13. Tobias JD, Mencio GA, Atwood R, Gurwitz GS. Intraoperative cardiopulmonary resuscitation in the prone position. J Pediatr Surg. 1994;29(12):1537-1538. doi:10.1016/0022-3468(94)90208-9
14. Mazer SP, Weisfeldt M, Bai D, et al. Reverse CPR: a pilot study of CPR in the prone position. Resuscitation. 2003;57(3):279-285. doi:10.1016/s0300-9572(03)00037-6
15. Wei J, Tung D, Sue SH, Wu SV, Chuang YC, Chang CY. Cardiopulmonary resuscitation in prone position: a simplified method for outpatients. J Chin Med Assoc. 2006;69(5):202-206. doi:10.1016/S1726-4901(09)70219-9
16. Dooney N. Prone CPR for transient asystole during lumbosacral spinal surgery. Anaesth Intensive Care. 2010;38(1):212-213
17. Haffner E, Sostarich AM, Fösel T. Erfolgreiche kardiopulmonale Reanimation in Bauchlage [Successful cardiopulmonary resuscitation in prone position]. Anaesthesist. 2010;59(12):1099-1101. doi:10.1007/s00101-010-1785-8
18. Burki AM. CPR in prone position during neurosurgery. Anaesthesia, Pain & Intensive Care. 2019 May 9
19. Beltran SL, Mashour GA. Unsuccessful cardiopulmonary resuscitation during neurosurgery: is the supine position always optimal?. The Journal of the American Society of Anesthesiologists. 2008 Jan 1;108(1):163-4