

Perioperative Management of the Pediatric Organ Donor

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ABSTRACT

Introduction: For bereaved families, organ donation does not take away from the pain and loss of death, but it does give some meaning at the time and a great deal of comfort later. Each and every family whose child has suffered brain stem death should be offered the chance to donate. When a diagnosis of brain death has been made in a child, it may be possible for organ donation to occur, but it requires optimization of the donor and meticulous planning. There are a number of medical, nursing, ethical, psychological, and administrative issues which must be addressed in the perioperative period to facilitate the procurement of organs in good condition. **Aim:** This review aims to provide up to date information and provides the clinical pathway used in our tertiary level, university-affiliated children's hospital for the management of the child in the critical care unit before organ donation, and intraoperative anaesthetic management. **Method:** This review was prepared using literature and clinical guidelines which were obtained from Medline and EMBASE databases, using the following search terms: Organ donation; intensive care management of organ donor; paediatric; neonatal; transplant outcome; and graft outcome. The focused literature search was carried out in 2017 by the five authors involved in the project. **Results:** The Society of Critical Care Medicine published consensus based guidelines for donor management in adult patients in 2015. Many of the core critical care principles in this document are similar in infants and children; although there are different considerations with respect to the diagnosis of brain death, consent, and pharmacological management. Full-text papers were employed by the project group to update our clinical pathway for the perioperative management of the infant or child who is a potential organ donor. Providing critical care medical and nursing staff with a pathway may improve communication, confidence, and delivery of care to the deceased child, their family and the graft recipients in this challenging situation.

Key words: Organ donation, paediatric, perioperative

INTRODUCTION

For bereaved families, organ donation does not take away from the pain and loss of death, but it does give some meaning at the time and a great deal of comfort later. Each and every family whose child has suffered brain stem death should be offered the chance to donate. At the time of death, donation may not come automatically to the minds of potential donor families. It is the responsibility of staff caring for the child and family to consider organ donation and to refer all potential cases.^[1,2]

When a diagnosis of brain death has been made in a child, it may be possible for organ donation to occur, but it requires optimization of the donor and meticulous planning. There are a number of medical, nursing, ethical, psychological, and administrative issues which must be addressed in the perioperative period to facilitate the procurement of organs in good condition. The condition of the grafted organ is critically important in the short- and long-term for the recipient.^[3,4] The devastating diagnosis of brain death is traumatic for parents and family, and for health-care staff involved in the care of the child. The emotional distress produced by such an event and

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the psychological support required during the period before and after organ procurement cannot be emphasized enough. A well-prepared multidisciplinary team approach assists in the competent and meticulous medical care required.^[5]

This review aims to provide up to date information and provides the clinical pathway used in our tertiary level, university-affiliated children's hospital for the management of the child in the critical care unit before organ donation, and intraoperative anesthetic management [Appendix 1].

METHODS

This review was prepared using literature and clinical guidelines which were obtained from Medline and EMBASE databases, using the following search terms: Organ donation; intensive care management of organ donor; pediatric; neonatal; transplant outcome; and graft outcome. The focused literature search was carried out in 2017 by the five authors involved in the project, with each paper cross-checked with the agreed search strategy. Searches were limited to the English language. Literature obtained was graded according to the level of evidence is provided.^[6]

RESULTS

There was a lack of level 1 or 2 evidence for management of pediatric organ donors. Published literature over the past two decades was made up of mostly case reports, case series and single center narrative, or descriptive studies. Available literature concentrated on the adult population. Full-text papers were employed by the project group to update our clinical pathway for the perioperative management of the infant or child who is a potential organ donor.

Critical care management

Significant injury to brain tissue may occur through a variety of mechanisms. The most frequent cause in infants and children is hypoxia and hypoperfusion. Direct, blunt trauma is the second leading cause of brain injury in this age group.^[7] Resuscitation of infants and children after a cardiac arrest following drowning, strangulation, shaking, or acute life-threatening events may produce hypoxic brain injury. This manifests in the following 48–72 h after injury, leading to massive cerebral edema and herniation of the cerebellar tonsils through the foramen magnum. This prevents arterial blood flow into the brain and venous flow out, and the brain dies as a result. Diagnosis of brain death is a clinical one, based on brainstem tests carried out by two physicians independently. Any physiological derangement or medication which might explain unconsciousness in a child must be excluded before brain stem tests are performed.^[8] In some situations, the clinical examination may be supported by ancillary investigations, for example, electroencephalography (EEG)

and cerebral angiography. Brain stem death is defined as irreversible structural brain damage leading to no possibility of independent existence.^[9]

Diagnosis of brain death is possible from 37 week's gestation onwards. Guidelines for diagnosis in neonates and young infants are provided by a joint working group in the Royal College of Pediatrics and Child Health, published in 2015.^[10] In infants less than 4 weeks corrected gestational age, EEG is recommended in addition to clinical tests. There may be potential to expand donor numbers if donations increase among infants.^[11] After completion of brainstem death tests the patient may be declared legally dead, and discussions regarding the donation of organs may proceed. The pediatric patient may be considered eligible for further screening if there is no evidence of untreated sepsis, malignancy (non-central nervous system), or positive virology (hepatitis B, C, and HIV).^[8]

There may be contraindications to the donation of specific organs due to the donor's medical condition, which the transplant coordinator will help to assess and discuss with family.^[9]

Consent for pediatric organ donation

The death of an infant or child is enormously distressing for their parents and family. Brain stem death is a particularly difficult and distressing subject to discuss with families; therefore, consistency of information is vital in gaining trust, and continuity is essential. The intensive care unit needs to provide a private and dignified environment, with support from social workers, psychologists, and pastoral or spiritual care. Nursing and medical staff may also benefit from formal and informal support at the time of the child's death, and in the days and weeks after.

Formal brain death testing is legally required if there is the prospect of organ donation.^[8]

The best time to raise the possibility of organ donation is between the two sets of brain stem tests. If the family does not agree to organ donation, the second set of brainstem tests is not necessary for intensive care supports to be ceased.^[12]

The family should be told what the tests involve, why they are being done and given the prognosis. This is best done in a quiet room where there will not be any interruptions. In certain circumstances, it may not always be appropriate to wait until brain stem testing has been performed before broaching the subject of organ donation with families. This depends on the family's understanding of their child's condition and their awareness of potential organ donation. It is vitally important that the parents understand the concept of brain death.^[13] It is often necessary to have two separate conversations, one to ensure that the futility of continuing treatment is fully understood, and the second to open the discussion of potential organ donation.

There are no rules as to who can approach the parents. Usually, it is a nurse or doctor who has been caring for the child and who has built up a rapport with the family. There are studies which suggest that the nurse at the bedside may have an important role in facilitating this discussion.^[14] Parents may require written material and/or radiological images to support their understanding. Initiating discussion about potential organ donation can only take place after the child's parents have understood and accepted that death is inevitable, or has occurred. With increasing public awareness of friends or neighbors waiting for heart, lung, liver and kidney transplants, parents now frequently start the conversation about organ donation, in the "what happens now?" phase as death is accepted.^[15]

Referral to the organ donation team should occur in a timely manner to ensure a full assessment of organ donation potential can be made. In countries such as Croatia and Spain where donation rates have increased dramatically over the past decade, families are approached by trained, dedicated organ procurement staff.^[13] This strategy has the advantage of separating the critical care physician and nurse from the procurement process but may result in the loss of the rapport gained with the intensive care staff. A combination of the intensive care specialists with the coordinator from the procurement service may represent the optimum team to introduce the theme of organ donation with the bereaved parents and obtain consent for donation.^[12] Written consent for organ donation, including detailed discussion of which organs are to be removed, is usually obtained by the transplant coordinator. Using experience from European transplant services which have progressed "opt-out" legislation and active enrolment of donors, teams which have received specific training in organ donation and procurement are better prepared to answer questions that families may raise about the donation process.^[16] In some circumstances, additional support may be requested from pastors of particular faiths to assist the child's parents in making the best decision for their family.^[17]

In many cases where the cause of brain stem death in the child or infant is not clearly due to natural causes or needs further investigation (as per Coroner's guidelines), the coroner must be informed by the medical team involved in the care of the patient and permission requested for organ retrieval for transplantation. Legal process must be facilitated as a part of planned organ procurement. The coroner may request a postmortem on the remains after organ procurement, or place limitations on the transplant procedures.

Confirmation of donor eligibility and completion of consent are time sensitive as injury to brain tissue, compounded by cessation of perfusion causes the release of tissue thromboplastin into the systemic circulation. This instigates a series of multi-system changes in function, culminating

in terminal hypotension and asystole. Cardiac death generally occurs 12–72 h after cerebral death if not actively managed.^[12] Critical care management of this time period may enhance organ perfusion and produces a short window of relative hemodynamic stability during which it is possible to transfer the legally deceased patient to the operating room and procure organs for transplantation.

Medical and nursing management of the pediatric organ donor

If the child is declared brain dead and the parents agree to organ donation, then the change in clinical approach is from treatment to limit or prevent neurological damage, to an approach that focuses on preserving the function of specific organs. By managing the donor carefully at this stage, the chances of survival can be improved in the transplant recipient.^[4]

Brain death may be accompanied by loss of vasomotor tone, loss of hormonal support, and hypothermia.^[1] Basic critical care monitoring with hourly fluid input and output measurement, pulse oximetry, arterial blood pressure, central venous pressure, and core temperature measurement are continued, and the information gained is used to optimize oxygen delivery and perfusion to the organs. At present, in Ireland, elective cannulation of the aorta with extracorporeal support to mimic physiological perfusion is not accepted practice, although it is carried out in other European countries.^[16] Physiological monitoring is combined with 12 hourly laboratory testing of full blood count, urea and creatinine, liver enzymes, coagulation parameters, blood gases and glucose, and daily microbiological cultures.^[18]

Understanding the physiological changes which will occur following brain death allows the medical team to manage the anticipated deterioration in cardiac, respiratory, renal, and endocrine function.^[19,20] Pharmacological management forms the mainstay of this period in the intensive care unit, before expediting transfer to the operating room.^[21,22]

Hemodynamic management

Direct injury to the myocardium may have occurred during resuscitation due to a combination of hypoperfusion, metabolic acidosis, repeated epinephrine boluses, and chest compressions. As a result, the child may require relatively high doses of inotropic infusions to deliver a mean arterial pressure appropriate for their age. Some major pediatric transplant centers find that reducing adrenaline and noradrenaline doses and employing vasopressin instead or in combination may be more effective at maintaining adequate blood pressure.^[21] As part of the endocrine management liothyronine and corticosteroids administration assists in blood pressure control, and usually facilitates the reduction in adrenaline/noradrenaline and vasopressin.^[23-25] Cardiac grafts which have

required high dose inotropes or endured a prolonged period of resuscitation may be less suitable for transplantation.^[26] Tissue pre- and post-conditioning techniques are now being used before grafting into the recipient to improve outcomes from marginal donors.^[27] Post-transplantation support with extracorporeal life support is also carried out if the donor heart does not achieve initial adequate contractility or the grafted lungs do not permit adequate gas exchange.^[28] The aim of perioperative critical care management is to improve cardiac perfusion and obviate the need for additional support in the recipient. Adequate cardiac and tissue perfusion are monitored using repeated lactate and base deficit measurement, echocardiography and evidence of end-organ perfusion, for example, urine output and renal indices.

If an arrhythmia occurs, serum electrolyte levels should be corrected. It is reasonable to perform cardioversion if the patient becomes hemodynamically unstable, for example, atrial flutter during central line placement; however, prolonged resuscitation is not ethically appropriate as the patient is legally dead and will not benefit from resuscitation.

Respiratory management

Pulmonary dysfunction is common in the organ donor due to pneumonia, aspiration of gastric contents, neurogenic pulmonary edema, or acute respiratory distress syndrome (which may be secondary to brain injury). As trauma is a major cause of death in young children, patients who have sustained significant brain injury frequently have thoracic trauma and lung contusions. This contributes to the challenge of achieving adequate gas exchange during the perioperative period. Early aggressive fluid resuscitation later contributes to this challenge.

The trachea should be intubated with a cuffed endotracheal tube appropriate for the child's age, to prevent aspiration. The lungs must be ventilated using a lung-protective strategy to reduce the possibility of ventilator-induced lung injury.^[29] Relative fluid restriction during the perioperative period may assist in preventing pulmonary edema from developing.^[30] If there are signs of sepsis such as elevated white cell count, C-reactive protein or dirty secretions on suctioning the lungs, bronchoalveolar lavage should be carried out, and antibiotic therapy commenced to treat the possible pulmonary infection. There may be a role for chest physiotherapy in the management of infection and clearing of secretions.

Endocrine management

Death of the pituitary and hypothalamus means that the patient no longer has circulating thyroid and cortisol and requires replacement of same. Methylprednisolone is widely used, in combination with liothyronine infusion [Appendix 1]. Loss of circulating antidiuretic hormone results in diabetes insipidus, with polyuria, dehydration, and hypernatremia. The diagnosis is confirmed by measuring the urine osmolality

which will be inappropriate >300 mOsm/L. Less antidiuretic hormone may be needed to manage the consequences of diabetes insipidus if the patient is receiving vasopressin to support their blood pressure. Some patients, however, will require administration of additional desmopressin if their urine output exceeds 4 ml/kg/h. Serum electrolytes should be measured frequently, and the urine volume plus 10% is replaced with appropriate fluids.^[6] This will replace volume deficits and decrease the serum sodium in a controlled fashion. Deceased donors with evidence of acute kidney injury may still donate their kidneys, although the incidence of delayed graft function is higher, the overall outcomes are good in the longer term.^[31]

Gastrointestinal management

Patients should be administered regular proton pump inhibitors to reduce the possibility of gastric stress ulceration. Early commencement of laxatives can be helpful in preventing constipation. Glycemic control may be managed with enteral feeding and continuous infusion of insulin if necessary, aiming for blood glucose level between 5 and 8 mmol/L. Good glycemic control may improve outcomes in renal grafts.^[32] If total parenteral nutritional is already been prescribed, it may be continued to assist with glycemic management. Nasogastric feeds may be continued to assist in nutritional support of the organs. It is important that the infant or child's parents understand the aim of nutritional support in this context, and that there is no conflict with the acceptance of death in the child. Enteral feeds should be stopped 4 h before organ procurement.

Hematological management

It is advised that tissue typing in preparation for procurement and identification of a suitable recipient is carried out early. The procurement team requires verification of the donor's blood group to commence this process.

Disorder in the coagulation system mediated by circulating tissue thromboplastin starts rapidly after brain death. Transfusion of red cells has an effect on the immune system of the donor, and on the immune system of the recipient, so transfusion is restricted and targeted cautiously to optimize oxygen delivery to the tissues. Coagulopathy should be corrected with administration of platelets and or plasma. Consultation with an experienced hematologist may be required in more difficult cases.^[8]

Regulation of normothermia

Hypothermia is common in organ donors due to loss of thermoregulatory control, also exposure to cool ambient temperatures or infusions of cold intravenous fluids or blood products. The consequences of hypothermia include arrhythmias, myocardial depression, hypotension, hypoxia, hyperglycemia, and coagulopathy. Aim for a core temperature

>36°C. Active measures are often needed including warming blankets, fluid warmers, and heated humidifiers in ventilator circuits.^[9]

Intraoperative management of the pediatric organ donor

Maintenance of relative physiological stability is the aim of the intraoperative management. The child's parents may request that they accompany their child to the operating room. If possible, the medical and nursing teams should facilitate this request as it is important that parents and family continue their trust and rapport with the team in the operating room.^[33] A respectful and dignified atmosphere is a key element in the care of the infant or child donor, as the ethical duty to the deceased's family, endures. The child is transferred with full critical care monitoring and continuation of vasoactive infusions. The surgical team receives care of the deceased donor, and the family and intensive care staff leave at this point. The family may be brought to a private room separate from the critical care unit and the operating room to preserve their privacy.

The anesthesiologist is required to provide meticulous attention to detail during the surgery.^[34] For multiple organ procurement procedures, a midline laparotomy and sternotomy are usually performed. Surgical dissection and retrieval of the organs can cause significant hemodynamic instability and large blood loss.^[35] In addition to maintaining inotropic infusions commenced in the critical care unit; the anesthesiologist will usually administer neuromuscular blockers to reduce the activity of spinal reflexes.^[36] Hypertension may be managed using vasodilators, opiates, or volatile anesthetic agents. In addition, volatile anesthetics may induce ischemic preconditioning in hepatic and cardiac surgery. For this reason, some retrieval teams administer them during the past 30 min before aortic clamping.^[37]

Post-operative care of the pediatric organ donor

After organ procurement, the deceased child's remains are brought from the operating room to the hospital mortuary. Some families may wish to view the remains and spend time in the mortuary with them. Cultural and religious death rituals commence at this time, and it is helpful if hospital staff can assist in facilitating these practices. The death of a child and donation of their organs can have a profound effect on nursing and medical staff, and additional support should be available to those who wish to access it.^[38]

CONCLUSION

The Society of Critical Care Medicine published consensus-based guidelines for donor management in adult patients in 2015.^[39] Many of the core critical care principles in this document are similar in infants and children; however, there are different considerations with respect to the diagnosis of brain death, consent, and pharmacological management.

Our review is intended to bring together the knowledge gained from the available adult and pediatric literature and produces a clinical pathway which is easy to follow in our 23-bed pediatric critical care unit [Appendix 1]. Providing critical care medical and nursing staff with a pathway may improve communication, confidence, and delivery of care to the deceased child, their family and the graft recipients in this challenging situation.

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APPENDIX 1

Medical and nursing care of the pediatric donor patient - clinical pathway

Following a diagnosis of death by brainstem death criteria, or a decision to withdraw active treatment due to medical futility, the pediatric patient may then be considered for organ donation. This can only take place if the child's parents or guardians understand and agree to a donation of organs following death. After consent for donation, clinical management to optimally preserve transplantable organs may be undertaken.

1. Diagnosis of death by brainstem death criteria or diagnosis of irretrievable severe brain injury. This diagnosis is usually made using clinical examination, knowledge of mechanism of injury, and radiological confirmation on CT brain or MRI brain.
2. Contact social work and chaplaincy. Contact psychology and psychiatry if indicated.
3. MDT discussion with parents of diagnosis and potential organ donation. Parents need time after meeting to think about donation.
4. Expression of parental wishes. In the event of parental decline of organ donation, brainstem tests do not need to be carried out, and pediatric critical care management is continued as appropriate.
5. Inquiry to Organ Donor Transplant Ireland (ODTI) regarding potential organ donation. This facilitates commencement of ODTI preparation.
6. Cease intravenous and enteral sedative medication (morphine, oxycodone, fentanyl, midazolam, lorazepam, promethazine, chloral hydrate, thiopentone, and propofol).
7. Carry out standard pediatric intensive care unit (PICU) memory-making and photography.
8. Commence pharmacological optimization. There are standardized medication order sets for organ donor management on ICIP (e-prescribing). The order set includes methylprednisolone, liothyronine, desmopressin, vasopressin, and esomeprazole.
9. Target hemodynamic support, effective ventilation/oxygenation, and fluid/electrolyte management for organ optimization.
10. Confirmatory tests if appropriate, for example, cerebral angiography and EEG.
11. Brainstem test 1 using the accepted criteria. Document the test and results in ICIP.
12. If brainstem tests are not appropriate, then donation after cardiac death (DCD) may be facilitated.
13. Telephone contact with coroner if indicated.
14. Contact with ODTI Transplant Coordinator with patient name, date of birth, blood group, weight, and height of a child in cm.
15. Draw blood samples for bottles in Organ Donation pack. This is 80ml of blood samples - this is a large volume of blood so consider giving a fluid bolus iv before taking samples. In children < 10kg, discuss samples with the Transplant Coordinator. These samples are divided into 2 boxes and sent for virology and tissue typing.
16. Obtain 12 lead ECG, Echocardiogram, and CXR, and official reports of same. ECHO report needs to include estimation of *ejection fraction*; please specify this requirement when requesting ECHO. Fax copy of blood group report, CXR and ECHO report to the Donor Coordinator's office.
17. CK and troponin levels may be requested by the Transplant team.
18. Contact Consultant Pathologist to discuss if postmortem necessary after organ retrieval.
19. Inform Theatre Coordinator of planned organ retrieval as space needs to be made on the Emergency list.
20. Brainstem test 2. Time of death is time of completion of brainstem test 2.

Consider bringing parents into the child's room when awaiting completion of 10 min apnea test, so that they are present at the time of death.

21. Transplant Coordinator comes to PICU and completes Health and Lifestyle Questionnaire and consent with infant/child's parents.
22. If the child is also for a Coroner's PM, formal identification with the police will be required. The local police station usually facilitates this quickly when contacted.
23. Child is transferred to the operating room. Parents may accompany if they wish. Parents must be given clear direction when it is time to leave the OR with the PICU nurse.
24. After surgery, the child is transferred to the mortuary or the butterfly room in PICU. The parents will meet the Consultant Pathologist in PICU or the Mortuary Chapel if there is to be a postmortem examination. The time of the meeting needs to be arranged with the Pathologist.

Discharge note and time of death recorded in PAS/ICIP. All notes printed off and filed in chart. *Time of death is time of completion of brainstem test 2.*