Anesthetic Management of an Adult Brain-Dead Organ Donor: A Quality Improvement Project

Rebecca VanWinkle, MSN

rebecca.vanwinkle@bryanhealthcollege.edu

Bryan College of Health Sciences, Lincoln, Nebraska

Abstract

Objective: Anesthesia plays a critical role in the management of an adult brain-dead donor. It is imperative that the anesthesia provider understand the pathophysiology of brain death and its subsequent effects on the body, hemodynamic maintenance, lung recruitment strategies, fluid and electrolyte balance, hormone replacement therapy, and the use of other pertinent medications. Failure to comprehend can result in improper management and may lead to the inability to recover and transplant organs. The purpose of this quality improvement project is to determine if an educational module to describe best practice for organ donation for certified registered nurse anesthesia providers (CRNA) will help improve knowledge base regarding anesthetic management of an adult brain-dead donor patient.

Methods: Forty-one participants completed a pretest on the anesthetic management of an adult brain-dead donor. Following completion of the pretest, an educational module was presented. After presentation of the module, a posttest was completed by all participants. Scores of both the pretest and posttest were recorded and analyzed.

Results: The Wilcoxon Signed Ranks test was utilized to compare differences between pretest and posttest scores. The data was found to be statistically significant. In all forty-one participants, posttest scores were improved compared to pretest scores after an educational module was presented.

Conclusion: This study demonstrated that the use of an educational module for anesthetic management of adult brain-dead donors increases knowledge of CRNAs in the care of this specialized population.

Introduction

Anesthesia plays a significant role in the management of a donor patient. The need for organ donation has been a growing issue as the general population becomes increasingly unhealthy, but the problem lies with a shortage of donor organs for transplantation.[1]

There are numerous reasons why potential donor patients are unable to donate their organs and/or tissue. Family decline or absence of patient registration to donate is a big contributor to this problem. The donor could also be initially ruled out for medical reasons. For example, the patient may be an oncology patient and it would be unsafe to transplant those potentially diseased organs. Another scenario is if the donor patient rapidly declines and there is not adequate time to allocate organs for transplantation. Finally, improper management of the donor patient may prevent organ donation.

Anesthesia providers have a great responsibility once they assume care of the organ donor in the operating room and evidence in the literature has shown that anesthesia plays a pivotal role in the management of a donor patient.[2] Not being comfortable or properly educated on the anesthetic management of a brain-dead donor can potentially jeopardize the donor's organs and result in the inability to transplant.

There are currently over 114,000 individuals in the United States who are waiting for an organ transplant to change and/or save their life.[3] Of those 114,000, over 75,000 are actively on the waiting list.[3] One organ donor can save up to eight lives and improve the lives of thousands more by also donating eyes and tissue, while up to 20 individuals die every day waiting for a transplant.[3] The magnitude of these numbers cannot be ignored. Organ donation has the potential to affect thousands of people each and every day. As of September 3, 2019, there have been over 19,000 donors from January, 2019 to June, 2019.[3] The donor, the donor's families, the recipient,

and the recipient's families all have an impact or are impacted by donation and there are many medical providers that are directly involved with the care of a donor patient, including anesthesia.

Methods

First, institutional review board approval was obtained. Population for this research study included CRNAs attending the Nebraska Association of Nurse Anesthetist's (NANA) Fall Conference at Bryan College of Health Sciences. Purposive sampling was used to identify this sample of CRNAs, which represent a small portion of CRNAs nationally. Inclusion criteria included current practicing and licensed CRNAs in attendance at the NANA Fall Conference. Participants must speak and read fluent English. Exclusion criteria included students of registered nurse anesthesia schools that were also in attendance.

On October 12, 2019 the study was described to the prospective participants by the principle investigator (PI), along with a description of the risks/benefits for potential participants. Packets to include pretest and posttest were distributed. It was explained to participants that participation in the study implies consent. Informed consent was typed and included on the top of the pretest and posttest. See Appendix A for informed consent. Pretest demographic information was explained, and participants were asked to fill this out. Participants were asked not to place identifying marks or names on their pre or posttest. It was explained to the willing participants that the pretest and posttest would be handed out in a numbered envelope, along with a writing utensil. The participants were asked to complete the pretest (composed of 20 questions) without help from their peers or electronic devices and place it in their assigned envelope. See Appendix B for pretest questions and answers. Ten minutes were allotted for completion of the pretest.

Next, a 30-minute educational module regarding anesthetic management of an adult brain-dead donor was presented by the PI.

Following the educational module, participants were asked to complete the attached posttest to re-assess knowledge gained. See Appendix C for the educational module presented. Comfortability questions were not used in this study. The order of the posttest questions and answers were altered to accommodate for any familiarity that may have been gained from the pretest. See Appendix D for posttest questions and answers. Neither their personal identity nor their scores will be released or revealed. Ten minutes were allotted for completion of the posttest. Participants were asked to place the posttest into their assigned envelope. Envelopes were then collected. Participants were thanked again for their participation and their time.

Data was analyzed using SPSS. Descriptive statistics were used to analyze demographic information including age, practice environment, and years of anesthesia practice. Participant's posttest scores were compared to participant's pretest scores. Statistical significance was determined by a p value of <0.5. Final aggregate data was disseminated via manuscript.

Educational Module Material

Brain Death Donation

In order to understand the anesthetic considerations of caring for an adult brain-dead donor, it is important to first acquire knowledge of the process of donation, the pathophysiology of the patient's underlying conditions, and the subsequent plan for organ recovery. The process of organ recovery begins when a patient is declared brain dead and there are certain criteria that needs to be met for confirmation. All other reversible causes or other differential diagnoses should be ruled out before brain death testing and assessment of reflexes are performed.[4] Testing for brain death confirmation can vary, but is recommended as follows:

> 1. Lack of spontaneous movement, with the recognition that spinal reflexes may remain intact. 2. Lack of all cranial nerve reflexes and function. The includes the failure of heart rate to increase more than five beats per minute in response to intravenously (preferably centrally) administered 0.04mg/kg atropine, which suggests loss of vagal nuclear, and thus tonic vagal nerve, function. 3. Positive result on an apnea test indicating lack of function of the respiratory control nuclei in the brainstem. The test is performed by initially ensuring a PaCO2 of 40 plus or minus 5mmHg and an arterial pH of 7.35-7.45. The patient is then ventilated with 100% oxygen for at least 10 minutes. Then while vital signs are monitored and the trachea is insufflated with 100% oxygen, mechanical ventilation is discontinued for 10 minutes. Arterial blood gas values are obtained at five- and ten-minutes following cessation of mechanical ventilation, and the patient is observed for signs of spontaneous respiration. Given that hypercarbia (PaCO2 >60mmHg) is a potent stimulus for ventilation, if no respiratory activity is noted, the result of the apnea test is deemed positive.[4]

Depending on what state you are practicing in, there are a variety of other tests that may need to be performed to make the diagnosis of brain death in addition to the above at the physician's discretion. In the Organ Procurement Organization in the State of Nebraska, determining the absence of reflexes, a thorough clinical exam, and apnea testing must be done before the diagnosis of brain death can be made.

In most cases, family has been approached about the opportunity for their loved one to donate their organs prior to brain death testing. After brain death is confirmed, the process of ensuring all organs are optimized for donation begins. This is when the medical team can proceed with optimizing oxygenation and perfusion to the donor's organs for recovery. It is

important to note that any provider involved with the transplant process not be involved in the declaration of brain death, nor that the topic of donation be brought up to family before this point in time at the discretion of the organ management team.[5]

The process of brain death can cause significant hemodynamic instability, which can impact other organ systems and eventually lead to organ ischemia. It can also lead to "wide swings in hormone levels, systemic inflammation, and oxidant stress."[5] Although clinical presentation leading up to brain death and thereafter can vary significantly from patient to patient, there is a general, hemodynamic trend with brain death. Most commonly, onset of brain death is associated with increases in tissue perfusion and cardiac index, along with transient periods of low blood pressure, leading to eventual brain death.[5] Brain death also has the potential to cause an autonomic storm, which can cause the patient's hemodynamics and laboratory results to shift up and down considerably.[5] Bradycardia that is unresponsive to atropine due to vagus nerve loss, further catecholamine release, and ultimate pituitary failure result.[5] Other considerations of a brain dead donor include the possible development of; "arrythmias, pulmonary edema, disseminated intravascular coagulation (DIC), hyperglycemia, diabetes insipidus, and hypothermia."[6]

Care of the brain-dead donor will then be transferred to the staff at Live On Nebraska (LON) with the help of other services and allocation will begin once the organs have been optimized for transplant. This timeline can vary between donors based upon which organs are being considered for donation. There may need to be further laboratory studies, echocardiography, cardiac catheterization, bronchoscopy, and other diagnostic evaluations prior to donation.[5] Additional time may need to be taken to optimize organs for transplantation. Once

everything is prepared, an operating room and an estimated time for recovery will be set. Instability of the patient with need for expedition of this process is always a possibility.

A thorough preoperative evaluation of the patient before transport to the operating room and delivery of anesthesia is of the upmost importance. The preoperative evaluation should include, but not limited to, past medical history, physical exam, laboratory values, blood type and verification of available products, cause of death, diagnostic results of all exams performed throughout hospital stay, biopsy results if applicable, and what organs will be recovered.[2] It is important to discuss the plan in its entirety from transport to the intensive care unit to the operating room with the donor management team so there are no discrepancies in the plan of care. Hemodynamic goals and other pertinent goals for anesthetic management should also be discussed prior to transport to the operating room. Declaration of death, cause of death, consent, and blood typing with consent should also be verified.[5]

It is recommended that the anesthesia provider accompany the team from the intensive care unit to the operating room due to the fragility of these patients. Regardless of lung recovery, it is also recommended that the patient remain on the ventilator setting unchanged from the intensive care unit or be transported with a positive end-expiratory pressure (PEEP) valve to maintain oxygenation and perfusion, not only to the lungs, but other vital organs.[5] In the event that the patient becomes unstable on the transport to the operating room, attention will be made to maintaining hemodynamic stability and blood flow to all organs. In the case of cardiac arrest, chest compressions must be initiated, the anesthesia provider may need to give heparin, and the process of organ recovery will be accelerated.[2]

The role of anesthesia in the management of a brain-dead donor patient is critical in the successful recovery of organs. Anesthesia's goals of care are to maintain organ perfusion and

prevent organ dysfunction with resuscitation and various other means, promoting adequate oxygenation, maintaining hemodynamic parameters, normalizing fluids and electrolytes while preserving appropriate urine output, and providing necessary medications to optimize the donor's organs with help from the surgeon and organ management team.[2]

Hemodynamic Maintenance

While management of a brain-dead donor can vary from the intensive care unit to the operating room, there are a specific set of guidelines that anesthesia is expected to adhere to intraoperatively to ensure hemodynamic stability. Intraoperative monitoring of the donor includes, but is not limited to; continuous electrocardiography with a heart rate between 90 and 120 beats/minute, pulse oximetry (SpO2), blood pressure via non-invasive or arterial monitoring, core temperature, end-tidal carbon dioxide (CO2), and central venous pressure (CVP).[2] For an adult donor, LON recommends a systolic blood pressure >90mmHg or a mean arterial pressure (MAP) >60, SpO2 maintained at 95%or higher, and, if applicable, a CVP of 6-10 mmHg.[7] Anesthesia should also confirm that there is sufficient intravenous access prior to initiation of the case, which may or may not include use of a central line.

In addition to the hemodynamic effects of brain death previously discussed, brain death also results in loss of thermoregulation, which can lead to catastrophic consequences. Cardiac dysrhythmias, DIC or other coagulopathies, and a reduction in oxygen delivery to organs being recovered can occur with hypothermia.[4] Delayed renal graft function has also been noted with temperatures of 34-35 degrees Celsius.[2] Maintaining a temperature between 36 and 37.5 degrees Celsius is recommended.[8]

Lung Recruitment Strategies

Currently, only 15-20% of lungs are being recovered from donors and the reason for this could be improper management and ineffective lung recruitment.[9] Lungs are the most susceptible organ to injury prior to recovery.[5] Studies show "that protective lung strategy in patients diagnosed with brain death could hinder the development of lung dysfunction and double the number of lungs available for transplantation."[9]Anesthesia providers are often not responsible for the care donors receive in the intensive care unit but are responsible for maintaining adequate perfusion and oxygenation to ensure recovery in the operating room.

Anesthesia providers should continue the donor's ICU ventilator settings, which includes, but is not limited to, positive end-expiratory pressure (PEEP), tidal volumes, and fractional inspired oxygen concentration (FiO2).[2] Per LON, it is ideal to maintain a PEEP of 5-8cmH2O or whatever is necessary for optimal lung recruitment and a tidal volume of 8-10mL/kg. It is also recommended to maintain a FiO2 of 100% or whatever necessary to maintain partial pressure of oxygen in arterial blood (PaO2) levels above 350-400mmHg to identify the functional level of the lungs.[10] Partial pressure of carbon dioxide in arterial blood (PaCO2) levels are targeted to normalize arterial blood gases and should be maintained perioperatively.[10] Preferred mode of ventilation and inspiratory: expiratory ratios are customized to each donor and their unique situation.[10] New research recommends a tidal volume of 6-8mL/kg and PaCO2 levels between 35mmHg and 45mmHg.[2] A FiO2 of 40% or less with a PEEP less than 7.5mmHg if lungs are to be recovered, is also encouraged.[2] Continued communication with the donor management team is critical to maintain perfusion to lungs and to prevent potentially catastrophic effects of an autonomic storm, such as pulmonary edema, infiltrates, and/or atelectasis.[10]

Fluid and Electrolyte Balance

Euvolemia is the goal of fluid balance in a donor with attention to avoid hypervolemia, which can lead to hepatic congestion, pulmonary edema, cardiac distention, and other potential complications of fluid overload.[4] Fluid overload can be detrimental to a potential organ donor patient. Although not specific to organ donor patients, there has been significant research on the topic of goal directed fluid therapy and its positive effects on intensive care patients.[11] Upon arrival to the operating room, the donor should be as optimized with fluid status as soon as possible. It is anesthesia's job to maintain fluid balance and continue any solutions that are currently being infused at the discretion of the organ management team. The use of a fluid warmer with any infusions should be considered to prevent hypothermia.[2]

A foley catheter or other means of urine monitoring should already be in place. Urine output should be assessed and documented every hour or more frequently, if necessary, and totaled at the end of the case.[7] Maintain urine output at 1-3ml/kg/hr with a CVP of 6-10mmHg or 4-8mmHg for potential lung donors.[8] A urine output <1ml/kg/hr or >3ml/kg/hr should be reported to the donor management team for further treatment. If hypovolemia is suspected with or without hypotension, the anesthesia provider is allowed to use isotonic crystalloids, albumin or other tissue expanders, and/or blood products to correct this imbalance.[7] Current recommendations are to maintain hemoglobin at 6 g/dL or greater and to guide the use of platelets, fresh frozen plasma, and other coagulation factors by usual clinical criteria.[2]

When treating hypotension, it is recommended to use fluids as a first line treatment, rather than vasopressors or inotropes, although there is not sufficient research on which medications are preferred if pharmacologic intervention of blood pressure is necessary.[2] It is recommended to discuss the use of medications to treat blood pressure with the donor

management team. Norepinephrine, vasopressin, dopamine, dobutamine, phenylephrine, and epinephrine have all been discussed throughout literature with variable results and recommendations.[2]

Similar to fluid balance, electrolytes should be corrected as much as possible prior to transport to the operating room. It may be necessary to draw a metabolic panel to monitor electrolytes while in the operating room and may be drawn at the discretion of the anesthesia provider or if the donor management team considers it necessary.[7]

Hormone Replacement Therapy

As previously discussed, brain death results in multisystem dysfunction. This dysfunction includes the rapid decline of hormone balance within the body. One of the largest retrospective studies was completed regarding the effectiveness of hormone replacement therapy, including thyroid hormone (triiodothyronine [T3] or levothyroxine [T4]), insulin, corticosteroids, and antidiuretic hormone (ADH), in donor patients from the year 2000-2009. It was found that "T3/T4 therapy was associated with procurement of significantly greater numbers of hearts, lungs, kidneys, pancreases, and intestines, but not livers."[12] Although, the use of T3/T4 in livers was not found to be harmful.[12] Without the correction of T3/T4 with hormone replacement therapy, the body will continue into anaerobic metabolism and lactate levels will continue to rise, which can prevent the recovery of organs.[2]

The loss of osmoregulation can also occur in a large population of patients who progress to brain death. These patients will likely develop diabetes insipidus and require ADH replacement with vasopressin or desmopressin.[2] In the retrospective study previously discussed, ADH replacement therapy was also found beneficial in organ recovery.[12]

This retrospective study also found that the administration of corticosteroids was less consistently favorable but also not harmful. Further analysis of the use of corticosteroids in brain-dead donors found that while corticosteroids have resulted in the increase of MAP and/or cardiac output, decrease in the use of vasopressors/inotropes for hypotension, and improved graft outcomes, further studies are recommended to gather more data.[12]

The current recommendation is to maintain blood glucose at less 180mg/dL.[2] In addition, current studies have shown that insulin administration specifically improved lung procurement and should be utilized with blood glucoses greater than 180mg/dL.[12] LON currently follows the policies and protocols of the hospital in which the recovery is occurring at for blood glucose management.

The initiation and continued infusion of hormone replacement therapies will have already been started by the donor management team. Anesthesia's role is to continue, discontinue, or adjust any of these infusions at the discretion of the donor management team.

Other Pertinent Medications

Anesthesia will also be responsible for the administration of other important medications. While it is not necessary for anesthesia or pain management, volatile agents may be initiated at the discretion of the anesthesia provider. It is important to consider the effects of volatile agents, but recent studies show that volatile agents may be beneficial in organ preconditioning.[2] Neuromuscular blockers are recommended prior to incision to control the donor's intact spinal motor reflexes.[2] The anesthesia provider will also give 300units/kg of heparin before the aorta is cross-clamped.[7]

It is imperative to have any medications that may be given available in the operating room. These medications include but are not limited to; vasopressors and/or inotropes as listed

above, heparin, corticosteroids, insulin, mannitol, lasix, T3/T4 infusions, neuromuscular blockers, preoperative antibiotics, crystalloids, colloids, and any other medications advised by the donor management team.

Results

SPSS21 was used for data analysis. Forty-one CRNA providers participated in the study. Patient demographic information included age groups, practice type, and years of anesthesia practice. Demographic information is presented in Tables 1, 2, and 3.

For the pretest and posttest, the Shapiro-Wilk's test of normality found normal distribution for the pretest. The posttest did not meet the test for the Shapiro-Wilk test for normality. Therefore, the non-parametric Wilcoxon Signed Ranks test was used to compare differences between pretest and posttest scores. Mean pretest scores were 9.780 and standard deviation was ±2.3507. Although, there were two outliers at the extremes of the range of the pretest. Mean posttest scores were 16.780 and standard deviation was ±1.6357. See Table 4. This was statistically significant at P value of .000. See Table 5. In all forty-one participants, posttest scores were improved compared to pretest scores after an educational module was presented. Therefore, knowledge was assumed to be increased.

Further data analysis was completed to closely examine if there were individual questions that a majority of the population answered incorrectly. There were eight questions that over 50% of the participants did not answer correctly. Table 6 displays each individual question, the number and percent of questions answered correctly on the pretest, and the number and percent of questions answered correctly on the posttest. Each individual question was addressed in the educational module. Table 6 shows that with each individual question there was an improvement in scores following the educational module. Again, showing that knowledge was increased.

Discussion

Anesthesia plays a pivotal role in the successful recovery of organs. The primary purpose of this study was to improve the participating CRNA's knowledge in the care of adult brain-dead donor patients to further increase knowledge and comfortability for future care. A major strength of this study was that educational material for the module was based on policies, protocols, and guidelines directly from LON and new evidence-based research.

Limitations of this study includes the test/retest effect with potential for recall regardless of rearrangement of questions and answers. Although participants were asked to keep pretests and posttests contained in envelope during the educational module, there was access to both tests throughout. There was also a potential for participants to cheat with the use their neighbor or electronic devices, regardless of verbal request not to. Also, the smaller sample size of 41 participants is not an adequate representative of the CRNA population. Further education could be implemented with improvement of the above limitations with a larger sample size.

In conclusion, this study identified that an educational module is useful to improve CRNA's knowledge of the anesthetic management of an adult brain-dead donor. Anesthesia's ability to continue adequate oxygenation and perfusion to organs for recovery is critical to promote a successful transplant.

References

1. Dare AJ, Bartlett AS, Fraser JF. Critical care of the potential organ donor. *Current Neurology and Neuroscience Reports*. 2012;12(4):456-465. doi:10.1007/s11910-012-0272-9.
2. Souter MJ, Eidbo E, Findlay JY, et al. Organ donor management: part 1. Toward a consensus to guide anesthesia services during donation after brain death. *Seminars in Cardiothoracic and Vascular Anesthesia*. 2018;22(2):211-222. doi:10.1177/1089253217749053.
3. United Network of Organ Sharing. Transplant Trends. https://unos.org/data/. Accessed September 3, 2019.
4. Pasternak JJ, Lanier WL. Diseases affecting the brain. In: Hines RL, Marschall KE. *Stoelting's Anesthesia and Co-Existing Disease.* 7th ed. Philadelphia: Elsevier; 2018.
5. Csete M, Manecke G, Banks D. Transplant anesthesia. In: Barash PG, Cullen BF, Stoelting RK, et al. *Clinical Anesthesia*. 8th ed. Philadelphia: Wolters Kluwer; 2017.
6. Anderson MJ, Willhite CJ. Anesthesia for organ transplantation. In: Nagelhout JJ, Elisha S. *Nurse Anesthesia*. 6th ed. St. Loius, Missouri: Elsevier; 2018.
7. Live On Nebraska. Anesthesia Intraoperative Support Guidelines. ORF.007. Revised December 24, 2018. Accessed August 1, 2018.
8. Live On Nebraska. Adult Donor Management Work Instruction. ORW.014. Revised June 13, 2016. Accessed August 1, 2019.
9. Miñambres E, Pérez-Villares JM, Terceros-Almanza L, et al. An intensive lung donor treatment protocol does not have negative influence on other grafts: a multicentre study. *Eur J Cardio-Thorac Surg Off J Eur Assoc Cardio-Thorac Surg*. 2016;49(6):1719-1724. doi:10.1093/ejcts/ezv454
10. Live On Nebraska. Lung Recruitment Worksheet. ORF.079. Updated December 2, 2018. Accessed August 1, 2019
11. Bednarczyk JM, Fridfinnson JA, Kumar A, et al. Incorporating dynamic assessment of

fluid responsiveness into goal-directed therapy: a systematic review and meta-analysis. *Crit Care Med*. 2017;45(9):1538-1545. doi:10.1097/CCM.0000000000002554

12. Novitzky D, Mi Z, Sun Q, Collins JF, Cooper DKC. Thyroid hormone therapy in the management of 63,593 brain-dead organ donors: a retrospective analysis. *Transplantation*. 2014;98(10):1119-1127. doi:10.1097/TP.0000000000000187

Appendix A

Informed Consent

The purpose of this quality improvement project is to determine if an educational module to describe best practice for organ donation for certified registered nurse anesthesia providers will help improve knowledge base regarding anesthetic management of an adult brain-dead donor patient. Risks of this study include loss of privacy should your questions be lost or misplaced. Every effort will be made to maintain privacy. No identifiers will be on the survey, so the risk is minimal. A potential benefit to the participants of this study include increasing knowledge base regarding the anesthetic management of a brain-dead donor.

Completion of the pre-test and post-test implies consent to participate in the project.

Participants may withdraw from the project at any time.

Appendix B

Anesthetic Management of an Adult Brain-Dead Organ Donor PreTest

1. Rate your comfort level in caring for an adult brain-dead donor patient.
   a. I have never cared for an adult brain-dead donor
   b. Not at all comfortable
   c. Slightly comfortable
   d. Moderately comfortable
   e. Very comfortable
   f. Extremely comfortable

2. Indicate the number of adult brain-dead donor patients you have cared for in the last year.
   a. 0
   b. 1-2
   c. 3-4
   d. ≥5, if so indicate_____

3. Which of the following health care professionals is able to pursue the family about potential donation prior to brain death?
   a. The attending physician
   b. The transplant surgeon
   c. The donor management team
   d. No one is able to mention donation prior to brain death

4. Approximately how many individuals are currently on the waiting list to receive a lifesaving organ transplant?
   a. 42,000
   b. 87,000
   c. 114,000
   d. 145,000

5. Which of the following is a physiological change as a result of brain death?
   a. Depression of adrenal function
   b. Increase in the production of T3/T4
   c. Hypoglycemia with increase in insulin secretion
   d. Increase in osmoregulation

6. Bradycardia, as a result of brain death, is unresponsive to which of the following?
   a. Epinephrine
   b. Dopamine
   c. Transcutaneous pacing
   d. Atropine

7. On route to the operating room the brain-dead donor patient experiences a cardiac arrest. What action should be taken?
   a. Immediate transfer to the operating room for recovery of organs
   b. Chest compressions with immediate transfer to the operating room for recovery of organs
   c. Declaration of death due to poor perfusion and oxygenation post cardiac arrest
   d. Chest compressions and return to ICU

8. Select the organ which is most susceptible to injury prior to organ recovery.
   a. Kidneys
   b. Heart
   c. Lungs
   d. Liver

9. What temperature should be maintained intraoperatively during organ recovery?
   a. 34.0-35.0 degrees Celsius
   b. 36.0-37.5 degrees Celsius
   c. 37.0-39.0 degrees Celsius
   d. Temperature is not an important parameter to maintain

10. The first line treatment for hypovolemia (with or without hypotension) includes which of the following?
   a. Crystalloids/Colloids/Blood products
   b. Hespan
   c. Vasopressors
   d. Inotropes

11. Which of the following is the preferred pharmacologic treatment of hypotension during the intraoperative period?
   a. Vasopressin
   b. Dopamine/Dobutamine
   c. Phenylephrine
   d. There is not a preferred treatment

12. Prior to incision, it is recommended to administer which of the following medications?
   a. Inhalational gases
   b. Neuromuscular blocker
   c. Heparin
   d. Albumin

13. Upon entry to the operating room, it is important to shut off which medication(s)?
   a. T4/Vasopressin
   b. Inotropes
   c. Infusing crystalloids/colloids
   d. None of the above

14. Heparin should be administered perioperatively at what time?
    a. Upon entry of the room
    b. Prior to incision
    c. Prior to aortic cross-clamp
    d. After aortic cross-clamp

15. When is it necessary to administer volatile agents?
    a. Immediately upon arrival to the operating room
    b. Prior to incision
    c. Prior to aortic clamping
    d. It is unnecessary to administer volatile agents

16. Maintaining a MAP >___ is necessary for brain-dead donors?
    a. >50mmHg
    b. >60mmHg
    c. >80mmHg
    d. >90mmHg

17. Select the correct Central Venous Pressure (CVP) ranges which should be maintained for adult organ donors and potential lung donors.
    a. 4-8mmHg, 0-4mmHg potential lung donors
    b. 6-10mmHg, 0-4mmHg potential lung donors
    c. 4-8mmHg, 4-8mmHg potential lung donors
    d. 6-10mmHg, 4-8mmHg potential lung donors

18. How often should the anesthesia provider analyze ABG's and electrolytes intraoperatively?
    a. Every 15 minutes
    b. Every 30 minutes
    c. Every hour
    d. At anesthesia's/donor management team's discretion

19. Heparin is administered at what dose?
    a. 100units/kg
    b. 300units/kg
    c. 500units/kg
    d. 750units/kg

20. Select the appropriate PEEP value to use for an adult brain-dead donor?
    a. 10-12cmH2O
    b. 0-5cmH2O
    c. 5-8cmH2O
    d. NO PEEP

Appendix B

Educational Module

Anesthetic Management of an Adult Brain-Dead Organ Donor

Bryan College of Health Sciences
Rebecca K. VanWinkle, RN, MSN, SRNA

Objectives

1. Significance of this Problem
2. Brain Death Donation Criteria and Approach
3. Hemodynamic Instability
4. Events Leading to Donation
5. Anesthesia's Role
6. Hemodynamic Monitoring
7. Lung Recruitment Strategies
8. Fluid and Electrolyte Balance
9. Hormone Replacement Therapy
10. Other Pertinent Medications

History

- First Kidney Transplant in 1954[1]
- First Liver Transplant in 1967[1]
- First Heart/Lung Transplant in 1981[1]
- First Living Donor Liver Transplant in 1989[1]
- In 2001, the total of living donors for the year exceeded the number of deceased donors[1]

Significance

- Shortage of Donor Organs[2]
- Reasons for Inability to Donate
- Anesthesia's Impact[3]
- Approximately 114,000 on the Waiting List[4]

Brain Death Donation

- Brain Death Criteria[5]
  - Clinical exam
  - Absence of reflexes
  - Apnea testing
- Family Approach
  - No one is able to mention donation PRIOR TO brain death[6]

Hemodynamic Instability

- Onset of Brain Death
  - Increases in tissue perfusion and cardiac index[6]
  - Transient periods of low blood pressure[6]
  - Eventual brain death[6]
  - Autonomic storm[6]
  - Hemodynamic shifting[6]

Hemodynamic Instability

- Onset of Brain Death
  - Bradycardia that is unresponsive to atropine due to vagus nerve loss[6]
  - Further catecholamine release[6]
  - Ultimate pituitary failure[6]
  - Other considerations[7]

Brain Death Donation

- Involvement of Live On Nebraska
- Evaluation Prior to Donation
- Importance of Communication

Brain Death Donation

- Transport from ICU to OR
  - Maintain ventilatory settings and PEEP[6]
  - In the case of cardiac arrest, chest compressions must be initiated, the anesthesia provider may need to give heparin, and the process of organ recovery will be accelerated[3]

Anesthesia's Role

1. Maintain Organ Perfusion[3]
2. Prevent Organ Dysfunction[3]
3. Promote Adequate Oxygenation[3]
4. Maintain Hemodynamic Parameters[3]
5. Normalize Fluids and Electrolytes[3]
6. Preserve Appropriate Urine Output[3]
7. Provide Necessary Medications[3]

Donation Myths Busted

- The oldest donor was 93 years old[8]
- There is no cost to the donor's family[8]
- Ethnicity, race, income, celebrity, and/or sexual orientation are not a factor in organ placement[8]

Hemodynamic Monitoring

- ECG with a heart rate
  - 90-120 beats/minute[9]
- SpO2
  - ≥ 95%[9]
- BP via non-invasive or arterial line
  - SBP >90 mmHg or a MAP >60 mmHg[9]
- End Tidal CO2
  - 35-45 mmHg[9]
- CVP
  - 6-10 mmHg[3]

Consequences of Ineffective Anesthetic Management of Temperature

- Cardiac Effects[5]
- Coagulopathies[5]
- Oxygen Delivery[5]
- Delayed Graft Function[3]
- Core Temperature
  - Goal: 36-37.5 degrees Celsius[10]

Lung Recruitment Strategies

- Most Susceptible Organ to Injury Before Recovery[6]
- Importance of Protective Lung Strategies[11]

Lung Recruitment Strategies

- Continue previous ventilatory settings from ICU[3]
- PEEP 5-8cmH2O[12]
- Tidal volume 8-10mL/kg[12]
- FiO2 100%[12]
  - Maintain PaO2 350-400mmHg[12]
- PaCO2 levels to achieve satisfactory ABGs[12]
- Mode of ventilation/I:E ratio[12]
- New research[3]

Fluid and Electrolyte Balance

- Detrimental Effects of Hypervolemia[5]
- Anesthesia's Role
  - Maintain fluid balance[5]
  - Continue infusions[3]
  - Fluid warmer[3]

Fluid and Electrolyte Balance

- Foley Catheter for Urine Output Monitoring[9]
  - Document urine output every hour or more[9]
  - Maintain urine output at 1-3ml/kg/hr[10]
- Maintain CVP of 6-10[10]
  - 4-8 for potential lung donors[10]
- Report Urine Output <1ml/kg/hr or >3ml/kg/hr[10]
- For Hypovolemia with or without Hypotension:
  - Isotonic crystalloids[9]
  - Albumin or other tissue expanders[9]
  - Blood products[9]
  - Maintain hemoglobin at ≥ 6g/dL[3]

Hypotension

- FLUIDS as a first line treatment[3]
- Insufficient research on preferred pharmacologic intervention[3]
- Maintain communication with the donor management team.
- ABG's and electrolytes at anesthesia's/donor management team's discretion[9]

Hormone Replacement Therapy

- Multisystem dysfunction leads to rapid decline of hormone balance and depression of adrenal function[3,14]

T3 and T4[3,14]
ADH[3,14]
Corticosteroids[14]
Insulin[3,14]

Other Pertinent Medications

- Volatile Agents
  - Initiation is not necessary[3]
- Neuromuscular Blockers
  - Recommended to administer neuromuscular blockers prior to incision[3]
- Heparin
  - 300 units/kg BEFORE the aorta is cross-clamped[9]

References

1. United Network of Organ Sharing. History. http://unos.org/transplant/history/. Accessed September 3, 2019.

2. Dare A, Bartlett A, Fraser J. Critical care of the potential organ donor. *Curr Neurol Neurosci Rep*. https://doi-org.ezproxy.bryanlgh.org/10.1007/s11910-012-0272-9.

3. Souter MJ, Eidbo E, Findlay JY, et al. Organ Donor Management: Part 1. Toward a Consensus to Guide Anesthesia Services During Donation After Brain Death. *Semin Cardiothorac Vasc Anesth*. 2018;22(2):211-222. doi:10.1177/1089253217749053

4. United Network of Organ Sharing. Transplant Trends. https://unos.org/data/. Accessed February 24, 2019.

5. Roberta L. Hines, Marschall, Katherine E. *Stoelting's Anesthesia and Co-Existing Disease*. 7th ed. Philadelphia: Elsevier; 2018.

6. Barash PG, Cullen BF, Stoelting RK, et al. *Clinical Anesthesia*. 8th ed. Philadelphia: Wolters Kluwer

References

7. Nagelhout JJ, Elisha S. *Nurse Anesthesia*. 6th ed. St. Loius, Missouri: Elsevier; 2018.

8. Health Resources and Services Administration. Organ donation myths and facts. https://www.organdonor.gov/about/facts-terms/donation-myths-facts.html. Accessed September 3, 2019.

9. Live On Nebraska. Anesthesia Intraoperative Support Guidelines. 2019.

10. Live On Nebraska. Adult Donor Management Work Instruction. 2019.

11. Miñambres E, Pérez-Villares JM, Terceros-Almanza L, et al. An intensive lung donor treatment protocol does not have negative influence on other grafts: a multicentre study. *Eur J Cardio-Thorac Surg Off J Eur Assoc Cardio-Thorac Surg*. 2016;49(6):1719-1724. doi:10.1093/ejcts/ezv454

12. Live On Nebraska. Lung Recruitment Worksheet. 12/262018.

13. Bednarczyk JM, Fridfinnson JA, Kumar A, et al. Incorporating Dynamic Assessment of Fluid Responsiveness Into Goal-Directed Therapy: A Systematic Review and Meta-Analysis. *Crit Care Med*. 2017;45(9):1538-1545. doi:10.1097/CCM.0000000000002554

14. Novitzky D, Mi Z, Sun Q, Collins JF, Cooper DKC. Thyroid hormone therapy in the management of 63,593 brain-dead organ donors: a retrospective analysis. *Transplantation*. 2014;98(10):1119-1127. doi:10.1097/TP.0000000000000187

Resources for Potential Risk Exposure

Bryan Medical Center
Emergency Room
1600 S. 48th St.
Lincoln, NE 68506
(402) 481-1111

Live on Nebraska
Family Support Department
3867 Leavenworth St.
Omaha, NE 68105
(402) 733-1800

Appendix D

Anesthetic Management of an Adult Brain-Dead Organ Donor PostTest

1. After receiving the following education, how much has your comfortability changed in regard to caring for an adult brain-dead donor patient?
   g. No improvement
   h. Slightly improved
   i. Moderately improved
   j. Very improved
   k. Extremely improved

2. Select the organ which is most susceptible to injury prior to organ recovery.
   e. Liver
   f. Lungs
   g. Heart
   h. Kidneys

3. Bradycardia, as a result of brain death, is unresponsive to which of the following?
   e. Transcutaneous pacing
   f. Epinephrine
   g. Atropine
   h. Dopamine

4. The first line treatment for hypovolemia (with or without hypotension) includes which of the following?
   a. Vasopressors
   b. Inotropes
   c. Crystalloids/Colloids/Blood products
   d. Hespan

5. Heparin is administered at what dose?
   e. 750units/kg
   f. 500units/kg
   g. 300units/kg
   h. 100units/kg

6. When is it necessary to administer volatile agents?
   e. Immediately upon arrival to the operating room
   f. Prior to aortic clamping
   g. It is unnecessary to administer volatile agents
   h. Prior to incision

7. How often should the anesthesia provider analyze ABG's and electrolytes intraoperatively?
   e. At anesthesia's/donor management team's discretion
   f. Every 15 minutes
   g. Every 30 minutes
   h. Every hour

8. Which of the following is a physiological change as a result of brain death?
   e. Increase in osmoregulation
   f. Increase in the production of T3/T4
   g. Depression of adrenal function
   h. Hypoglycemia with increase in insulin secretion

9. Select the appropriate PEEP value to use for an adult brain-dead donor?
   e. 10-12cmH2O
   f. 0-5cmH2O
   g. 5-8cmH2O
   h. NO PEEP

10. Upon entry to the operating room, it is important to shut off which medication(s)?
   e. T4/Vasopressin
   f. Inotropes
   g. Infusing crystalloids/colloids
   h. None of the above

11. Heparin should be administered perioperatively at what time?
   e. After aortic cross-clamp
   f. Upon entry of the room
   g. Prior to aortic cross-clamp
   h. Prior to incision

12. Maintaining a MAP >___ is necessary for brain-dead donors?
   e. >90mmHg
   f. >70mmHg
   g. >60mmHg
   h. >80mmHg

13. Which of the following health care professionals is able to pursue the family about potential donation prior to brain death?
   e. No one is able to mention donation prior to brain death
   f. The attending physician
   g. The transplant surgeon
   h. The donor management team

14. Approximately how many individuals are currently on the waiting list?
    e. 87,000
    f. 145,000
    g. 42,000
    h. 114,000

15. On route to the operating room the brain-dead donor patient experiences a cardiac arrest. What action should be taken?
    e. Chest compressions and return to ICU
    f. Chest compressions with immediate transfer to the operating room for recovery of organs
    g. Declaration of death due to poor perfusion and oxygenation post cardiac arrest
    h. Immediate transfer to the operating room for recovery of organs

16. Prior to incision, it is recommended to administer which of the following medications?
    e. Neuromuscular blocker
    f. Inhalational gases
    g. Albumin
    h. Heparin

17. Which of the following is the preferred pharmacologic treatment of hypotension during the intraoperative period?
    e. **There is not a preferred treatment**
    f. Dopamine/Dobutamine
    g. Phenylephrine
    h. Vasopressin

18. What temperature should be maintained intraoperatively during organ recovery?
    e. Temperature is not an important parameter to maintain
    f. 34.0-35.0 degrees Celsius
    g. 37.0-39.0 degrees Celsius
    h. 36.0-37.5 degrees Celsius

19. Select the correct Central Venous Pressure (CVP) ranges which should be maintained for adult organ donors and potential lung donors.
    e. 4-8mmHg, 4-8mmHg potential lung donors
    f. 4-8mmHg, 0-4mmHg potential lung donors
    g. 6-10mmHg, 4-8mmHg potential lung donors
    h. 6-10mmHg, 0-4mmHg potential lung donors

Table 1

Age Groups

Age Groups	Frequency	Percent
26-30	3	7.3
31-35	8	19.5
36-40	6	14.6
41-45	6	14.6
46-50	4	9..8
51-55	2	4.9
56-60	4	9.8
61-65	4	9.8
>65	4	9.8
Total	41	100.0

Table 2

Practice Type

Practice Type	Frequency	Percent
Academic	10	24.4
Private	15	36.6
Rural	16	39.0
Total	41	100.0

Table 3

Years of Anesthesia Practice

Years of Practice	Frequency	Percent
<1	4	9.8
1-5	9	22.0
6-10	9	22.0
11-15	3	7.3
16-20	2	4.9
>20	14	34.1
Total	41	100.0

Table 4

Wilcoxon Signed Ranks Test

	N	Mean	Std. Deviation
Pretest	41	9.780	±2.3507
Posttest	41	16.780	±1.6357

Note: The Wilcoxon Signed Ranks Test showed statically significant differences between pretest and posttest sore ($P<.05$).

Table 6

Frequency Distribution of Itemized Questions

Question	Correct on Pretest (%)	Correct on Posttest (%)
Which of the following is the preferred pharmacologic treatment of hypotension during the intraoperative period?	4/41 (10%)	34/41 (83%)
Approximately how many individuals are currently on the waiting list to receive a lifesaving organ transplant?	10/41 (24%)	37/41 (90%)
Select the organ which is most susceptible to injury prior to organ recovery.	11/41 (27%)	39/41 (95%)
Heparin is administered at what dose?	14/41 (34%)	39/41 (95%)
Select the correct Central Venous Pressure (CVP) ranges which should be maintained for adult organ donors and potential lung donors.	18/41 (44%)	37/41 (90%)
Which of the following health care professionals is able to pursue the family about potential donation prior to brain death?	18/41 (44%)	36/41 (88%)
How often should the anesthesia provider analyze ABG's and electrolytes intraoperatively?	20/41 (49%)	36/41 (88%)
Select the appropriate PEEP value to use for an adult brain-dead donor?	20/41 (49%)	38/41 (93%)
When is it necessary to administer volatile agents?	22/41 (54%)	39/41 (95%)
What temperature should be maintained intraoperatively during organ recovery?	22/41 (54%)	41/41 (100%)
Which of the following is a physiological change as a result of brain death?	25/41 (61%)	38/41 (93%)
Prior to incision, it is recommended to administer which of the following medications?	27/41 (66%)	39/41 (95%)
On route to the operating room the brain-dead donor patient experiences a cardiac arrest. What action should be taken?	28/41 (68%)	39/41 (95%)
Bradycardia, as a result of brain death, is unresponsive to which of the following?	28/41 (68%)	40/41 (98%)
Upon entry to the operating room, it is important to shut off which medication(s)?	32/41 (78%)	38/41 (93%)
Maintaining a MAP >___ is necessary for brain-dead donors?	33/41 (80%)	39/41 (95%)
Heparin should be administered perioperatively at what time?	35/41 (85%)	38/41 (93%)
The first line treatment for hypovolemia (with or without hypotension) includes which of the following?	37/41 (90%)	41/41 (100%)

Note: Answers to following questions and the pretest/posttest in its entirety found in Appendix A/B.