# Organ and Tissue Donations

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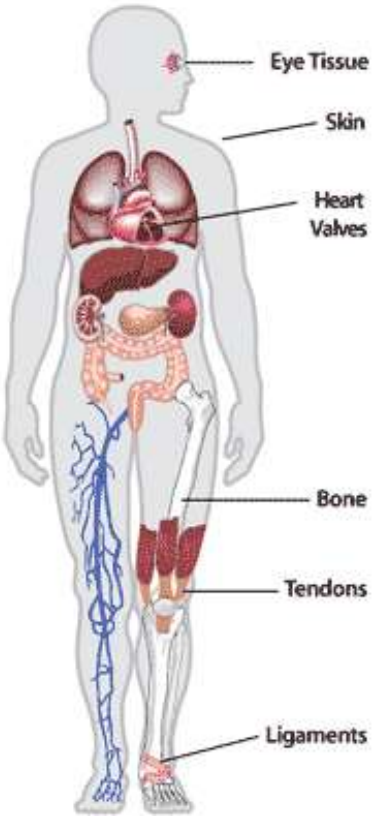
**Purpose** The purpose of this course is to describe the processes for identifying organ donors and obtaining consent, maintaining, recovering, and allocating organs and tissue.

**Goals** Upon completion of this course, the healthcare provider should be able to:

- Describe the history and current status of organ and tissue donations.
- List at least 6 organs and at least 6 tissues that can be donated and transplanted.
- Discuss legislation related to organ and tissue donation and transplantation.
- Explain the function of UNOS and OPOs.
- Explain the priority listing for obtaining consent.
- Discuss 4 steps on communicating with family and obtaining consent.
- Discuss 4 classes of donors.
- Explain brain death.




- Explain maintenance criteria for at least 8 areas of concern.
- Describe recovery procedures.
- Describe allocation protocols for 6 major organs.

## Introduction

The very first recorded tissue transplant was conducted in 1869 in Switzerland when a surgeon transplanted the skin of one person to another, but progress was slow. In 1906, the first corneal transplant was done, but it wasn't until 1954 that the first successful solid organ transplant was done in Boston with identical twins as the donor and recipient of a kidney. The first cadaveric

kidney transplant was completed in 1962 and followed the next year with lung and liver transplants.

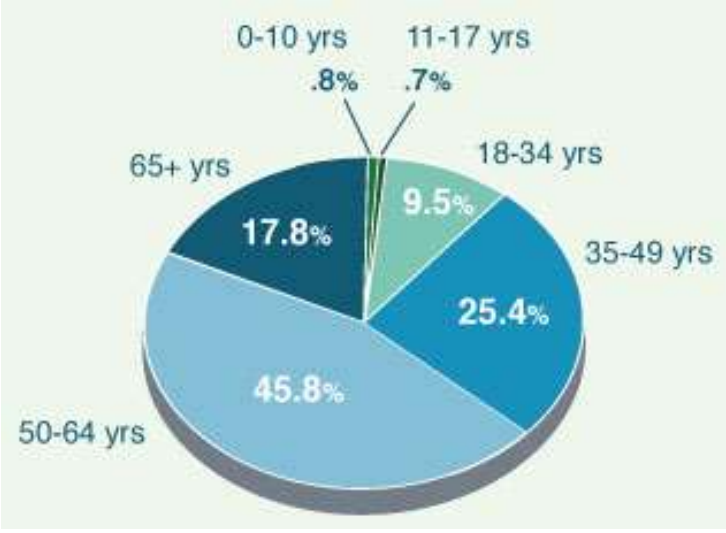
In 1968, a watershed moment in medical history, Dr. Christian Barnard of South Africa performed the first heart transplant. Since these pioneering efforts, there has been slow but steady progress in organ and tissue transplantation.

In 2008, the first successful near total face transplantation occurred followed in 2020 by a full facial transplant. In 2008, the first successful double arm transplant was completed in Germany, and in 2021, a double leg transplant was completed in Spain.

Over 28,000 people in the United States received organ transplants in the last year, and a million received tissue transplants, but the need far outstrips the availability of organs and tissue. Over 113,000 people are waiting for organ donations. Every 10 minutes a person is added to the waiting list, and 18 people die each day because no organ is available to them.

Early attempts at transplantation were hampered by rejection, so the introduction of Cyclosporin A (1983) had a profound effect on surgical outcomes and made possible the expansion of transplantation. Over the years, surgical and tissue typing techniques have improved as have methods to preserve organs. Additionally, the development of the heart-lung machine made possible transplantation of the heart and lungs. Advances in immunosuppression, including methods to reduce immunosuppression with newer drugs show promise for the future.

**Wait list candidates by age:**




In October 2009, 104,296 patients were on waiting lists:

- 81,884 waiting for a kidney
- 15,944 waiting for a liver.

- 1,496 waiting for a pancreas.
- 200 waiting for islet cells.
- 2187 waiting for kidney and pancreas.
- 226 waiting for intestines.
- 2888 waiting for a heart.
- 83 waiting for heart and lungs.
- 1876 waiting for lungs.

One donor has the potential to save the lives of 8 different people. Most people who die—at any age—could be potential organ and/or tissue donors.

| Organs | Tissue (including musculoskeletal) |
|---|---|
| • **Heart**<br>• **Lungs**<br>• **Liver**<br>• **Kidneys**<br>• **Pancreas**<br>• **Whole eyes**<br>• **Small intestines**<br>• **Thymus** | • **Corneas**<br>• **Heart valves**<br>• **Bone**<br>• **Tendons**<br>• **Ligaments**<br>• **Saphenous veins**<br>• **Skin**<br>• **Hand**<br>• **Face**<br>• **Arm**<br>• **Leg** |

## Legislation

In **1968**, the Uniform Anatomical Gift Act (UAGA) prohibited the buying and selling of organs and established a minimum age for donation (usually 18 without parental consent), and this was accepted by all states by **1972**. One result of the UAGA was development of the wallet-sized donation card, which is considered legally binding if properly completed. However, the reality is that OPOs usually seek consent from the legal next-of-kin. If the legal next-of-skin or designated person with power of attorney refuses to grant consent, then the dying or deceased wishes regarding tissue and/or organ donation may not be fulfilled even though recent updates of the laws support the legal right to proceed despite family objections.

In **1978**, the Uniform Determination of Death Act was passed and defined death as irreversible cessation of function of either the brain or heart and lungs. This law was further revised in 1980, and the criteria for brain death outlined by a Presidential Commission in **1981**. The Guidelines for Determination of Death are still in use.

In **1984**, the U.S. Congress passed the National Organ Transplant Act (NOTA), governing organ allocation. This act established the current national organ

transplant system. The Task Force on Organ Procurement and Transplantation was established as well as the Organ Procurement and Transplantation Network (OPTN) and the Association of Organ Procurement Organizations (AOPO). Prior to formation of the OPTN, there was no organized method of matching donors and recipients.

In **1986**, the Omnibus Reconciliation Transplant Act passed requiring that organ procurement organizations (OPOs) and transplant hospitals that participate in Medicare/Medicaid programs be members of the OPTN. The Health Care Financing Administration (HCFA) was given authority to certify OPOs, and the United Network for Organ Sharing (UNOS), a private non-profit organization, was awarded the contract to operate the OPTN. All patients waiting for transplants are entered into the UNOS centralized national computer network so they can be matched with donors.

Organ procurement organizations (OPOs) are responsible for procuring, preserving, and allocating all organs and tissues. OPOs are the liaisons between the local hospitals and the United Network for Organ Sharing (UNOS). Tissue transplants are regulated by the Food and Drug Administration to ensure that tissue is handled properly and to prevent the spread of communicable diseases.

OPOs are typically responsible for one or two states and allocate tissues and organs at three levels, beginning with level one and descending to other levels if no recipient match is found:

1. OPO's designated area.
2. OPO's designated region (usually encompassing a few states).
3. National distribution.

OPOs are responsible for dealing with consent issues, verifying pronouncement of death, and entering the donor into the UNOS national computer system, and ensuring that the proper UNOS organ allocation is carried out.

In **1987**, the UAGA was amended to require that hospital personnel ask all patients upon admission if they were organ donors or would consider being one. The amendment also establishes "presumed consent" for those who die without advance directive indicating wishes and for whom next-of-kin cannot be located. The amendment gives medical examiners or coroners the power to authorize donations. However, not all states have adopted the amendment.

In **1997**, the United States Department of Health and Human Services (HHS) required all hospitals to refer all deaths and imminent deaths to OPOs so that potential donors can be identified and next-of-kin asked about donation. To ensure that this policy is carried out, hospital staff, patients, family members, and members of the general public are encouraged to file complaints if the policy is

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not carried out or if it is done so in an inappropriate manner with the CMS, which will then investigate.

Additionally, HHS, which certifies OPOs, divided the United States into 60 areas (this number has varied, but there are currently 58) in 11 regions, with designated OPOs responsible for recovering organs and transporting them within each region.  Hospitals must also have an agreement with at least one eye bank and one tissue bank although in some cases tissue donations are handled by OPOs.

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In **2000**, the Final Rule was implemented, requiring standardized medical criteria to determine a patient's status and when the patient can be placed on a waiting list. The goal is for organs to be allocated according to need rather than simply allocated within a designated region.

In **2008**, further modification of the UAGA resulted in a requirement that hospitals have a policy in place to handle donation after cardiac death (DCD). This modification also expanded the list of those who can give consent and mandated that life support be maintained until the OPO can evaluate the patient as a potential donor.

## Identification, OPO Notification, and Consent

Each hospital should have a protocol established for OPO notification of death or imminent death. OPOs have **organ procurement coordinators** (OPCs) available to assist. In larger hospitals, OPCs assigned specifically to notify the OPOs and obtain consent, may be available, but in smaller facilities, these responsibilities may fall on **designated requesters.** OPOs also have OPCs available. Designated requestors must have completed a course offered or approved by the OPO to which the hospital reports. The course must be designed in conjunction with the tissue and eye bank community and should include methods of approaching donor families to request donations of organs and tissues.

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While physicians can be trained as designated requesters, this can pose some ethical concerns as the role of the physician is to act for the benefit of the patient and put the patient's needs first, but the role of the designated requester is to act for the benefit of potential donors. Additionally, neither the physician who attends the patient at the time of death nor the physician who actually determines the time of death may participate in procuring the patient's organs.

With imminent death, the OPO must be notified before the patient is removed from a ventilator and while the organs remain viable. Standards for imminent death should be available from the hospital's OPO. If a patient dies during transfer, the receiving hospital notifies the OPO. Deaths must be reported individually to the OPO and not saved and presented in a "batch."

The person notifying the OPO should have all pertinent information readily available, including information about advance directives, age, weight, height, ABOs, gender, diagnosis, medications, treatments, intravenous infusions, surgeries, and social history. While establishing a time frame for death can sometimes be difficult, the OPO should be notified within one hour of a sudden death and if possible at least an hour prior to death when death appears imminent.

Each organ or tissue that can be donated is evaluated individually for suitability. For example, if the heart is to be donated, evaluation might include a physical assessment, ECG, and echocardiogram as well as lab tests to evaluate cardiac enzymes. Risk factors, such as smoking and history of substance abuse or multiple sex partners are also assessed.

Laboratory testing routinely includes serology and may include a variety of other tests, such as for hepatitis B and C and HIV, depending on patient history and risk factors. Various measurements may be taken (such as chest and abdominal circumference). Lymph nodes and/or blood may be obtained for tissue typing. During this process the potential donor is maintained on life support.

The restrictions on organ donors have lessened over the years as the need for organs has outpaced donations and as transplantation techniques have improved. Even quite elderly adults may be considered as donors for some organs and tissue. Diseases, such as hypertension or diabetes, which previously precluded donation, may be acceptable. Some OPOs are even considering organ donations from those who are HIV or hepatitis C positive if the recipient is also positive.

Unless the dying or deceased patient has specifically given instructions NOT to donate, current regulations list seven classes of persons authorized to consent to donation on the deceased's behalf. Consent must be obtained in the following order of priority:

a) **Agent** of the deceased (holder of power of attorney for health care or

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expressly authorized to make an anatomical gift by a signed record).

b) **Spouse** or **state registered domestic partner** of the deceased.
c) **Adult child** of the deceased.
d) **Parents** of the deceased.
e) **Adult siblings** of the deceased.
f) **Adult grandchildren** of the deceased.
g) **Grandparents** of the deceased.
h) **Any person acting as the guardian** of the deceased at the time of death.
i) **Any other person** having authority under applicable law to dispose of the deceased's remains.

Communicating with the family or next of kin to request donation should follow a progression:

1. Discuss the seriousness of the patient's condition, explaining the type of injury or illness and the fact that the donor may not recover.
2. Describe the grave prognosis and discuss treatments and plan of care.
3. For patients with probable brain death, explain that testing is being done because it appears that the brain is not working, explaining the difference between coma and brain death. Also explain that the time of death recorded on the death certificate is the time that the patient is found to be brain dead.
4. Explain that brain death testing is completed and discuss results, explaining that the patient is legally dead.

It may be necessary to explain the concept of brain death more than once and to ask questions to ascertain that the family members really understand. It is at this point, after the family members understand that the patient is legally dead, that the OPC or certified designated requester talks to the family about organ and tissue donation.

The family should be apprised of donation options and recovery procedures and offered support services. Family should be reassured that the donor's body is not mutilated (and they can have an open coffin if they wish, and that there are no costs involved. Consent should be witnessed, signed, and dated. Once this is completed, the hospital supervisor should be notified and the medical examiner/coroner, who provides a release for donation. The procedure for donation is terminated if the family or medical examiner/coroner denies consent or the patient is deemed unsuitable.

At times, religion may be a consideration although most major religions accept or even encourage organ donation. Most Christian, Buddhist, and Hindu sects allow organ donation and transplantation although some may have restrictions. For example, organs transplanted into a Jehovah's Witness must be drained of blood

because of prohibitions against receiving blood transfusions, and the Catholic religion prohibits transplantation involving embryonic stem cells.

Islam allows for organ donation if the person has provided written permission prior to death. Most Jewish sects allow donation and some believe it to be obligatory if intended to save a life as long as the person is considered dead according to Jewish tradition. Some groups that prohibit donation or transplantation are those who practice Shintoism and the traditional Romani (Gypsies). However, the individual does not necessarily correspond to the group, so even those in groups that usually shun organ donation should be approached.

When a patient is declared brain dead, it's especially important that family members who must make decisions about organ donation understand that the person is already dead and that body functions are simply being maintained artificially because the person still, in many ways, appears to be alive: The body is warm, the heart is beating, and the lungs are functioning. Many people do not understand the differences among brain death, coma, and vegetative state.

During the consent process, the family members or other designated agents should be asked if they wish to be present when life support is removed if possible. With brain dead cadavers whose life support will be discontinued in the operating room as organs are removed, this may not be possible, but family should be given the opportunity to spend time with the donor to say goodbye.

## Classification of Donors

Deceased donors are classified in 3 ways:

- **Standard criteria donor** (SCD): Donors under 50 who suffered brain death. This category includes pediatric donors.
- **Extended criteria donor** (ECD): Includes donors =/>60 years or 50-59 years with disease, such as hypertension, death by cardiac disease or stroke, or terminal serum creatinine >1.5 mg/dl.
- **Donor after cardiac death** (DCD) (formerly non-heart-beating donor): Donors have suffered irreversible brain damage but do not meet formal brain death criteria. When the heart stops beating, the patient is declared dead and the organs can then be removed in the operating room. DCD results in some degree of oxygen deprivation to organs, so use of organs depends on how quickly they are recovered after death. Tissue remains viable for longer periods. DCDs may also fall into the SCD or ECD categories, depending on age and risk factors.

Most donors are SCD. ECD donors place the recipient at higher risk of failure but may be used if no other organ is available.

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**Donation after cardiac death** Criteria for donation after cardiac death includes patients who suffer devastating neurologic injury or other organ failure requiring ventilatory or circulatory support and family or care givers have initiated discussion about withdrawal of support.

These donors have conditions that are incompatible with life but are not brain dead. Conditions can include heart attacks with low flow of blood to the brain and high spinal cord injuries. Because these patients do not meet the criteria for brain death, the heart must stop beating prior to recovering of organs, usually after removal of life support.

For organs to remain viable, the heart must stop shortly after life support is terminated because prolonged periods of hypotension are damaging to the organs and may preclude their use for transplantation.

These donors are usually moved to the operating room for recovering of organs and/or tissue immediately after the heart stops, allowing the family to be with the donor during the last moments. The heart and intestines are not recovered with donation after cardiac death, but in some instances other organs may remain viable.

**Donation after brain death** **Brain death** is irreversible loss of brain function because of damage to the brainstem. Prior to a diagnosis of brain death, physicians must rule out hypothermia and drug and alcohol overdose as these may mimic brain death. Indications of brain death include loss of brain stem reflexes, including the ability to breathe independently. A finding of brain death must include coma or unresponsiveness and no cerebral motor response to pain in all extremities and supraorbital pressure. **Testing of brainstem reflexes** includes:

- Papillary response to light.
- Corneal reflex.
- Vestibular ocular reflex.
- Motor response to pain.
- Gag reflex (suctioning through endotracheal tube or tracheotomy).
- Persistent apnea despite a rise in $PaCO_2$ with normal $PaO_2$.

An **apnea test** is usually performed after the second examination of brainstem reflexes but is only performed one time if the findings are conclusive. A finding of brain death must be confirmed by two physicians and by total lack of electrical activity in the brain by two electroencephalograms taken 12 to 24 hours apart for organ donors. In most cases, no further confirmatory testing is necessary, but if severe injuries (such as skull or cervical injuries) preclude or prevent some testing, then sometimes confirmatory testing is indicated. Confirmatory tests can

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include angiography, nuclear brain scanning, somatosensory evoked potentials, and transcranial Doppler ultrasonography.

The criteria for finding **brain death in infants** varies according to age:

- 0-7 days: Reliable criteria have not been established.
- 7 days to 2 months: Two examinations and electroencephalograms (EEGs) should be separated by at least 48 hours.
- 2 months to one year: Two examinations and EEGs should be separated by at least 24 hours. A repeat examination and EEG are not necessary if a concomitant radionuclide (CRAG) or other angiographic study demonstrates no visualization of cerebral arteries.

The **time of death** is recorded at the time the diagnosis of brain death is made, not at the time the life support is removed. A **brain dead cadaver** is one that has suffered brain death after trauma, stroke, cardiac arrest, near-drowning or other event that resulted in lack of oxygen to the brain but has heart beat and respirations maintained through mechanical ventilation, fluids, and medications.

**Exclusion criteria** include:

- HIV infection (in almost all cases).
- Active cancer.
- Systemic infection.

**Living donors**

Approximately 6200 transplantations each year result from living donations with family members, friends, and even strangers providing organs to others. Exclusion criteria include uncontrolled hypertension, diabetes, HIV/AIDS, hepatitis, cancer, and organ disease. Living donors must be in good physical and mental health and be fully apprised of the risks involved. Donors must undergo medical and psychosocial evaluations.

Donations can be:

- Directed donations from family members, friends or others providing organs to specified recipients.
- Non-directed donations to recipients on the national waiting list.
- Paired donations or exchanges involving 2 or more pairs of donors and candidates.

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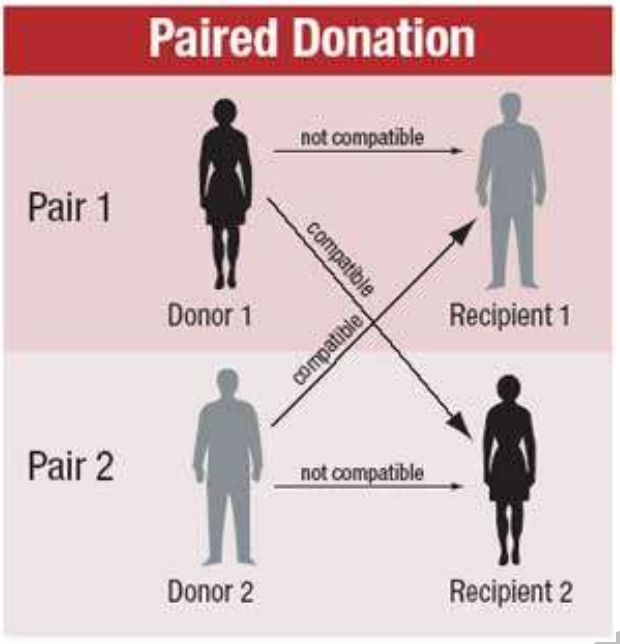


Organs that can be donated include:

- Kidney (entire organ).
- Liver (segment).
- Lung (lobe).
- Intestine (portion).
- Pancreas (portion).

It's especially important that the living donor feel no coercion regarding donation and should feel free to opt out. In 2007, UNOS provided guidelines suggesting that donors who change their minds should be provided a non-specific statement of unsuitability so that they can present an excuse and not feel pressured by family or friends.

## Maintenance and recovery

Once a donor is accepted, the organ procurement coordinator (OPC) usually manages maintenance procedures and treatments. Care during maintenance focuses on protecting organs and tissues through adequate perfusion and oxygenation. With damage to the brainstem, the autonomic nervous system control is lost and a number of problems begin to occur, including hemodynamic instability and tachyarrhythmias. Vascular tone diminishes, resulting in peripheral vascular dilation, reduced venous return, and hypotension.

Clotting mechanisms are impaired and can result in hemorrhage. The temperature control mechanisms of the hypothalamus no longer maintain body temperature, and about 85% of donors exhibit hypothermia.

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In some cases, treatments used to prevent damage to the brain (such as diuretics and hypertonic solutions) may impact maintenance. In addition to the ventilator, donors normally have a Foley catheter in place, an NG tube (used for tube feedings), and 2 large-bore arterial lines. Cardio-thoracic donors generally have a CVP/pulmonary artery catheter. These require routine care and monitoring as for any patient.

Donors should continue to receive routine care, such as skin care, turning, mouth care, and general hygiene as these measures may help to prevent complications and show respect for donor and for the concerns of the family.

**Respiratory** Mandatory ventilation is maintained and PEEP used. Arterial blood gases are monitored frequently. FiO2 should be adjusted as necessary. The goal is peak ventilation airway pressure <30 cm H20 and good respiratory function. Tidal volume is maintained at 10-15 mL/kg and a mild respiratory alkalosis (pCO2 30 to 35 mm Hg) is also maintained. Chest physiotherapy and suctioning may be needed to remove secretions.

Note: Notify OPC for PaO2 <90 or SaO2 <95%.

**Cardiovascular** Vital signs must be monitored at least every hour. Vasopressor support (dopamine is the drug of choice) may be needed to maintain systolic BP >90 mm Hg. Intravenous fluid challenge may be needed to ensure adequate filling. Mean arterial pressure should be maintained at 60 mm Hg and CVP of 5 to 10. Hypotension (MAP <60 mm Hg) is the most common cardiovascular problem after brain death and usually occurs soon after diagnosis. The most common cause is hypovolemia. Hypertension is rare but may occur in about half of patients during final stages of brain herniation, but the hypertension is self-limiting.

For cardio-thoracic donors, an early echocardiogram and insertion of PAC are necessary. A repeat echocardiogram is done when donor has stabilized. Donor is unstable if 2 of the following conditions that indicate stability are not met:

- Mean Arterial Pressure > 60
- CVP <12 mm Hg
- PCWP<12 mm Hg
- SVR 800-1200 dyne/sec/cm$^5$
- Cardiac Index > 2.5 l/min/M$^2$
- Left Ventricular Stroke Work Index > 15
- Dopamine dosage < 10 mcg/kg/min

Note: Notify OPC for BP <90 mm Hg systolic, heart rate <70 or >120, CVP <4 or >11.

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**Electrolyte/Metabolic** Electrolytes and ABOs must be monitored carefully and replacement electrolytes (especially potassium, calcium, phosphate and magnesium) provided as needed. Hypocalcemia, hypophosphatemia, and hypomagnesemia are common and often related to polyuria. Hypocalcemia may occur in donors aggressively transfused with blood.

- Sodium: Maintain at 135 to 150 mEq/L. Notify OPC for level >150 mEq.L. Hyponatremia is rare but may occur secondary to hyperglycemia. Hypernatremia may result from treatment prior to diagnosis.
- Potassium: Maintain at >4 mEq/L. About 90% of donors develop hypokalemia because of diuretics, polyuria, or alkalosis.
- pH: Maintain at 7.35 to 7.45.
-

Acidosis should be corrected with sodium bicarbonate and mild to moderate hyperventilation (pCO2 of 30-35 mm Hg). Clotting factors should be monitored and coagulopathy corrected by administration of appropriate clotting factors.

Note: Notify OPC for Hct <30/Hgb >10, PT >14 and PTT <28.

**Hydration** Hypovolemia is the primary cause of hemodynamic instability in the brain dead donor, so fluid IV fluids should be administered to maintain adequate hydration and blood pressure. Crystalloids, colloids, and blood products may be administered. For cardio-thoracic donors, colloids and avoidance of anemia are necessary to prevent pulmonary edema.

- Albumin: Normal PT and PTT.
- FFP: PT and PTT abnormal (=/>1.5 x control level).
- PRBC: Maintain PCWP of 8-12 mm Hg and Hgb >10 mg/dL.

Fluid resuscitation may cause dilutional coagulopathy. IV normal saline may result in increased sodium levels, so NS is usually avoided. Dextrose 5% may be necessary to keep sodium levels below 150 mEq/L. BUN and serum potassium should be evaluated after correcting fluid deficit.

**Hyperglycemia** Hypoglycemia rarely occurs in brain dead donors, but hyperglycemia is very common, resulting from stress injury, reduced insulin levels, and/or IV fluids containing glucose. The goal is to titrate glucose levels between 120 mg/dL and 180 mg/dL. An insulin drip is set at a minimum rate of 1unit/hour.

**Hormonal replacement** Hormonal replacement includes:

- Tri-iodothyronine (T3): 4 mcg bolus; 3 mcg/hr. continuous infusion.

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- Arginine Vasopressin: 1 unit bolus: 0.5 - 4.0 unit/hour drip (titrate SVR 800-1200 using a PA catheter).
- Methylprednisolone: 15 mg/kg bolus (Repeat q 24 hr. PRN).

**Oliguria management**

Diuretics may be necessary to increase urinary output. Urinary output should be maintained at a minimum of >0.5 mL/kg/hour.

Note: Notify OPC for urinary output <1 mL/Kg/hr.

**Diabetes insipidus**

With brain death, the pituitary gland stops production of antidiuretic hormone, resulting in diabetes insipidus, which can have a profound effect on fluid and electrolyte balances. Urinary output must be carefully monitored and fluids replaced mL per mL to prevent hypovolemia. Desmopressin 4 μg may be administered to slow output.

Note: Notify OPC for urinary output >3 mL/kg/hr.

**Hypothermia**

In many cases, the donors core temperature falls toward ambient temperature. As temperature falls, cardiac output decreases and hemodynamic instability increases with dysrhythmias. Hypothermia may also result in coagulopathy because it affects clotting factors. The goal of hypothermia management is to maintain normal temperature between 35°C and 37.8°C. Hypothermia is common, but the donor should be warmed slowly to avoid vasodilation that could drop mean arterial pressure. Warming may be done by warming blankets, warmed IV fluids, and/or warm bladder or NG irrigations.

**Spinal reflexes**

Up to 40 to 75% of brain dead donors have reflex movements. These can include jerking of fingers, plantar responses, muscle stretch reflexes, periodic leg movements, and abdominal reflexes. While the cause of movements isn't always completely understood, some relate to reflex arcs in which a neural pathway bypasses the brain. Another movement that can occur is referred to as the Lazarus sign or reflex. Movement can occur spontaneously or in response to painful stimuli. The reflex results in the arms briefly raised and then dropped across the chest.

Movement usually occurs within the first 24 hours after diagnosis of brain death and does not occur after 72 hours. Paralytics may be administered for reflex movements, which can be distressing to healthcare providers and family members.

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**Antibiotic prophylaxis** A broad-spectrum antibiotic should be administered.

## Recovery and Allocation

**Recovery** Organ and tissue recovery is completed in the operating room. Prior to transporting the donor, all members of the recovery team should be present and transport available to take recovered organs to recipients. (Donated tissue must be process before transplantation, so they cannot be transplanted immediately). Donors who are brain dead should be maintained on ventilation with Ambu bag and PEEP valve for transfer with portable O2 at 100% FiO2. Labs may be drawn in the OR and biopsies of some tissue may be completed.

In some cases, kidneys can be recovered up to an hour after death, but this is rare. Corneas and skin can be removed up to 2 hours after death, bone up to 36 hours, and heart valves up to 72 hours.

Hearts and lungs must usually be transplanted within 4 to 6 hours, liver and pancreas within 12 hours, and kidneys within 24 hours. Organs are transplanted at 4°C. A newer method of transporting organs, the Organ Care System, has been developed and maintains organs in a warm functioning state for longer periods. This type of transplant is referred to as a "living organ transplant" because the organ continues to function. This system is currently limited to investigational use in the United States.

**Allocation** In the beginning, organs were allocated according to recipient's time on the waiting list, but because there was little standardization, this method was not always the most ethical or effective, so criteria have been developed for different organs and tissues. UNOS determines allocation based on priorities for each type of organ/tissue.

| Organs | Allocation priorities |
|---|---|
| **Kidney** | • Local, regional, national sequence<br>• Priority:<br>  ○ Pediatric candidates.<br>  ○ High PRA candidates.<br>  ○ Zero or one DR mismatch.<br>  ○ Longest waiting time.<br>  ○ Prior living donors. |
| **Liver** | • MELD/PELD formula used to estimate likelihood of short-term death without transplant.<br>• Regional allocation first for most urgent candidates, then local, |

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| | |
|---|---|
| | regional, national.<br>• Exceptions made for hepatocellular carcinoma and rare conditions.<br>• Pediatric donor/candidate priority. |
| **Heart** | • Urgency priority based on level of intervention, including medications, left ventricular assist devices, etc.<br>• Local/zone allocation sequence (concentric circles from donor site).<br>• Pediatric donor candidate priority. |
| **Lungs** | • Lung Allocation System used to predict net benefit, score combines to evaluate likelihood of short-term death without transplantation and likelihood of longer-term survival.<br>• Exceptions made for those with rare conditions.<br>• Different criteria are used for pediatric candidates (0-11).<br>• Local/zone allocation sequence. |
| **Pancreas** | • Local/regional/national sequence<br>• Priority to high PRA candidates.<br>• Candidates with longest wait time.<br>• Islet recovery allowed for qualifying donors if whole organ is not accepted. |
| **Intestines** | • Urgency priority based on liver function, IV feeding access.<br>• Local/regional, and then national allocation.<br>• Priority for pediatric candidates.<br>• Liver/intestines or multi-organ combinations are usually allocated according to liver urgency and donor suitability. |

## Conclusion

Over 100,000 people are on waiting lists waiting for organ transplantations and the demand continues to grow. The Organ Procurement and Transplantation Network is operated by the United Network of Sharing (UNOS), which certifies organ procurement organizations, OPOs, which are responsible for procuring, preserving, and allocating all organs and tissues. The OPO is notified of all deaths and imminent deaths for evaluation of suitability for organ/tissue donation.

While consent is not necessary if a potential donor has completed a donor card or registered for organ donation, in most cases OPOs require consent of family or designated agent. Donors are classified as standard criteria donor, extended criteria donor, or donor after cardiac death. Living donors may also provide some types of organ donations.

Maintenance care focuses on protecting organs and tissue through adequate perfusion and oxygenation. This may require intensive treatment. The brain dead donor is maintained on mechanical ventilation until surgery to remove organs, but ventilation and other life support is removed from the donor after cardiac death to allow the heart to stop beating, after which tissue and

sometimes some organs can be recovered. UNOS determines allocation of organs and tissue, depending on priorities established for each type of organ/tissue.

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