Optimization of the Potential Organ Donor

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Professor of Surgery
Chief, Division of Trauma, Burns, Surgical Critical Care, and Emergency General Surgery
I have nothing to disclose
I have nothing to disclose

Except.....
Why should we know about donation??
The New Age of Transplantation

33,611 Transplants performed in 2016

15,946 Donors

118,213 on the waiting list
The Organ Shortage Problem

Waiting list

Transplants

19 deaths/day

7000/year
Centers for Medicare/Medicaid Services & ACS

- Notification process
- Declaration of brain death
- Organ procurement organization (OPO) relationship
- Performance Improvement (PI) program
- Patient/family opportunity to donate
Solid Organ Procurement
Level I, II, III Trauma Centers

- Must have an established relationship with a recognized OPO
- Must have a written policy for triggering notification of the regional OPO
- Must review its solid organ donation rate annually
- Must have written protocols defining clinical criteria and confirmatory tests for the diagnosis of brain death
Cause of Death of Donors

- 35% Other
- 40% CVA/Stroke
- 21% Anoxia
- 4% TBI
Outline

- Types of Donors
- Declaration of Brain Death
- Critical Care Management
Types of Donors

- **Living Donors**

- **Deceased Donors**
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Deceased and Living Donors 2004-2013 U.S.
Cadaveric “Brain Dead” Donors

Living donors 18%

Cadaveric donors 82%
Types of Donors

- Living Donors
- Deceased Donors
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Types of Donors

- **Deceased Donors**
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Two Ways to Declare Death

- **Cardiac Death**
  - Death declared on basis of cardiopulmonary criteria
  - Irreversible cessation of circulatory and respiratory function
  - DCD
  - 8% deceased donors

- **Brain Death**
  - Irreversible loss of all functions of the brain, including brain stem
  - Non-DCD or DBD
  - 92% deceased donors
Types of Donors

- Deceased Donors
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Declaring Brain Death

1. Pre-requisites
2. Clinical Examination
3. Ancillary Testing
4. Documentation & Organ Donation
Declaring Brain Death

1. Pre-requisites
2. Clinical Examination
3. Ancillary Testing
4. Documentation & Organ Donation
Pre-requisites

- Known proximal cause & irreversibility
- Absence of confounders
  - Electrolyte, metabolic, endocrine, acid-base disturbances
  - Intoxication/drug effects
**Pre-requisites**

- Known proximal cause & irreversibility
- Absence of confounders
  - Electrolyte, metabolic, endocrine, acid-base disturbances
  - Intoxication/drug effects

Hypothermia

- $> 36 \text{ C (from 32)}$
- Systolic Blood Pressure
  - $\geq 100 \text{ mm Hg (from 90)}$
Declaring Brain Death

1. Pre-requisites
2. Clinical Examination
3. Ancillary Testing
4. Documentation & Organ Donation
Motor response to painful stimuli

- Sternum
- Supraorbital nerve
- Nail bed

Adapted from: Wijdicks. NEJM. 2001
Clinical Exam: BRAINSTEM REFLEXES

- Pupillary Light Reflex
- Corneal Reflex
- Gag Reflex
- Oculocephalic Reflex (Dolls Eyes)
- Oculovestibular Reflex (Cold Calorics)
Clinical Exam: APNEA

- Absence of a breathing drive
  - Tested by CO2 challenge

- Prerequisites
  - Normotension
  - Normothermia
  - Euvolemia
  - Eucapnia (35-45)
  - Absence of hypoxia
Clinical Exam: APNEA

Apneic oxygenation-diffusion technique

Repeat ABG: 8 min

Arterial PCO2
• ≥ 60 mm Hg OR
• 20 mm Hg increase over baseline

Adapted from: Wijdicks. NEJM. 2001
Declaring Brain Death

1. Pre-requisites
2. Clinical Examination
3. Ancillary Testing
4. Documentation & Organ Donation
Ancillary Tests

Only if clinical exam incomplete, unreliable or unsafe

1. Brain perfusion scan
2. EEG
3. Transcranial doppler
4. Conventional angiography
Declaring Brain Death

1. Pre-requisites
2. Clinical Examination
3. Ancillary Testing
4. Documentation & Organ Donation
Documentation & Donation

Time of death:

- \( \text{pCO}_2 \) reached target value
- Ancillary test interpretation
Organ donation:

- Federal & State law requires contact with organ procurement association
- OPO to approach family
Organ Donor Timeline

- Injury
- 1st Brain death
- 2nd Brain Death
- Family consent
- OPO Management
- Organ Retrieval
Types of Donors

- Deceased Donors
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Types of Donors

- **Deceased Donors**
  - Donors after Neurologic Determination of Death
  - Donors after Circulatory Determination of Death
Timeline of DCDD

- Cessation of circulation/respiration
- Declaration of death and organ procurement
- Withdrawal of life support

2-5 min
Outline

- Types of Donors
- Declaration of Brain Death
- Critical Care Management
Outline

- Types of Donors
- Declaration of Brain Death
- Critical Care Management
Case review

- 23 yo male
- Transcranial GSW to head
- Visible brain matter
- GCS 3
- Pupils fixed – 4 mm
- Intubated, hypertonic saline, Head CT
Case review

- Cardiac Arrest in CT
- Resuscitated
- Coagulopathic
- Second cardiac arrest on arrival to SICU
- pH – 6.8, base deficit 25
Case review

- Multiorgan system failure
- Declared brain death
- Family/patient strong desire for organ donation
Case review

- Organ donation offered
Case review

- Organ donation offered
  - Liver
  - Heart
  - Both kidneys
Case review

- Why was he so sick??
Brainstem Ischemia

Catecholamine surge
↑HR, ↑BP, ↑CO, ↑SVR

Brainstem Herniation
Brain Death

- arrhythmias
- acidosis
- pulmonary edema
- hypotension
- DIC
- hypothermia
Complications of Brain Death

Brain Death

- arrhythmias
- pulmonary edema
- acidosis
- hypotension
- DIC
- hypothermia

cardiovascular collapse
Organ Loss up to 25%
Case review

- Cardiac Arrest in CT
- Resuscitated
- Coagulopathic
- Second cardiac arrest on arrival to SICU
- pH – 6.8, base deficit 25
Why?

Hemodynamic instability

- Autonomic dysfunction
- Aerobic to anaerobic metabolism
- Release of vasoactive inflammatory mediators
Elevation of pro-inflammatory cytokines

- IL-1 – 16%
- IL-6 – 100%
- TNF-α - 28%
- CRP – 98%
- PCT – 87%
Why?

Hemodynamic instability

- Autonomic dysfunction
- Aerobic to anaerobic metabolism
- Release of vasoactive inflammatory mediators
- Low levels of $T_3$, $T_4$, cortisol, insulin
- Reversal with replacement of $T_3$
The Role of thyroid hormone
Salim et al Arch Surg 2001;136:1377-1380

**T4 administration**

Time interval in hours
Time 0 is start of T4

<table>
<thead>
<tr>
<th>Time interval in hours</th>
<th>Total Vasopressor Dose (mcg/kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>15</td>
</tr>
<tr>
<td>-5</td>
<td>10</td>
</tr>
<tr>
<td>-4</td>
<td>10</td>
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<tr>
<td>-3</td>
<td>10</td>
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<tr>
<td>-2</td>
<td>10</td>
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<tr>
<td>-1</td>
<td>10</td>
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<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
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<tr>
<td>3</td>
<td>5</td>
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<tr>
<td>4</td>
<td>5</td>
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<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
Cardiovascular Collapse??

- A fluid problem……..
- A hormonal problem……
- An attention problem……..
Hypovolemia
- Absolute hypovolemia
- Initial injury
- Inadequate resuscitation
- Fluid leaking into interstitial space
- Decreased intravascular oncotic pressure after crystalloid resuscitation
- Treatment for intracranial pressure
- Fluid restriction
- Urea
- Diuretics
- Mannitol
- Hyperglycemia-induced osmotic diuresis
- Diabetes insipidus
- Hypothermic "cold" diuresis
- Effective hypovolemia
  - Loss of vasomotor tone and pooling in venous capacitance bed
  - Hypothermia treated with rewarming

Cardiac dysfunction
- Preexisting disease
- Initial injury
- Myocardial contusion
- Pericardial tamponade
- Myocardial ischemia or infarct
- Process of brain death
- Catecholamine damage
- Ischemia–reperfusion injury
- Metabolic depression
  - Acidosis
  - Hypothermia
  - Hypophosphatemia
  - Hypocalcemia
  - Hypoxia
  - Endocrinopathy of brain death
- Volume overload resulting in congestive heart failure
- Arrhythmias
  - Catecholamines
  - Ischemia
  - Hypokalemia
  - Hypomagnesemia

Vasodilatation
- Spinal shock
- Catecholamine depletion
- Loss of vasomotor control and autoregulation
- Relative adrenal insufficiency as a result of trauma or critical illness
- Endocrinopathy of brain death
- Acquired sepsis
Cardiovascular Collapse??

- A fluid problem……..
- A hormonal problem……..
- An attention problem……..

Donor management is key to preventing collapse
Organ Donor Timeline

1st Brain death

2nd Brain Death

Family consent

OPO Management

Injury

CVC

Organ Retrieval

ADM
What is Aggressive Donor Management?
What is Aggressive Donor Management?

- Hemodynamic Management
  - Invasive monitoring with endpoints
Hemodynamic Management

- Target criteria
  - MAP > 60
  - PCWP 8-12
  - CVP 4-12
  - CI > 2.4
  - SVR 800-1200
  - Dopamine < 10
What is Aggressive Donor Management?

- **Hemodynamic Management**
  - Invasive monitoring with endpoints
  - Hormonal therapy
    - T3 or T4
    - Methylprednisolone
    - Vasopressin
Hormone Therapy

- **Rapid IV bolus of:**
  - 1 amp 50% dextrose
  - 20 units insulin
  - 2 g Solumedrol
  - 20 mcg $T_4$

- **Continuous $T_4$ infusion at 10 mcg/h**

$T_4$ only used in **hemodynamically unstable donors** (combined vasopressor dose > 10mcg/kg/min)
The Role of thyroid hormone
Salim et al Arch Surg 2001;136:1377-1380

![Graph showing T4 administration and total vasopressor dose over time.]

- **Total Vasopressor Dose (mcg/kg/min)**
- **Time interval in hours**
- **Time 0 is start of T4**
Aggressive Donor Management

- PAC
- HRT (MP, T3, Insulin, Vasopressin)

52 “unacceptable” donors

Donor MGT

44 transplanted
What is Aggressive Donor Management?

- Ventilator Management
What is Aggressive Donor Management?

- Ventilator Management
  - Appropriate tidal volumes (10 cc/kg)
    - Prevent atelectasis
  - Recruitment maneuvers
  - Fluid restriction (diuretics)
  - Bronchoscopy (frequent suctioning)
  - Prevent aspiration (elevate HOB)
Aggressive management of lung donors classified as unacceptable: Excellent recipient survival one year after transplantation
Aggressive management of lung donors classified as unacceptable: Excellent recipient survival one year after transplantation

2002;124:250-258

- Aggressive management
  - CVP monitoring
  - Methylprednisolone 15 µg/kg
  - Fluid restriction
  - Diuresis
  - Inotropes titrated for stability
  - Bronchoscopy
Successful lung procurement can be optimized with aggressive donor management.
Donor Management
equals
More Organs
Instituting a User-Friendly Protocol

**Aggressive Donor Management**

(ADM)

Early identification  
Dedicated team fluids, pressors, $T_4$

ICU admission
Early identification of potential organ donor

ICU admission and management by dedicated ICU team

1. Pulmonary artery catheterization to monitor hemodynamic status and perfusion
2. Aggressive fluid resuscitation

MAP < 70

- Vasopressors
  - MAP < 70
    - T4 protocol administration
  - MAP ≥ 70
    - Supportive Care

MAP ≥ 70

- Supportive Care

Early identification and treatment of brain-death related complications

Diabetes Insipidus - Desmopressin; Vasopressin utilization if pressors required

Neurogenic Pulmonary Edema - Aggressive optimization of pulmonary function; utilization of high frequency percussive ventilation as indicated

Coagulopathy - Aggressive correction (FFP, cryoprecipitate, Factor VII utilization)

SIADH - Salt replacement with hypertonic saline, fluid restriction when appropriate
# Aggressive Organ Donor Management Significantly Increases the Number of Organs Available for Transplantation

Ali Salim, MD; George C. Velmahos, MD, PhD, FACS; Carlos Brown, MD; Howard Belzberg, MD; and Demetrios Demetriades, MD, PhD, FACS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Referrals for donation</td>
<td>341</td>
<td>537</td>
<td>+ 57%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Potential donors</td>
<td>214</td>
<td>255</td>
<td>+ 19%</td>
<td>0.01</td>
</tr>
<tr>
<td>Actual donors</td>
<td>57</td>
<td>104</td>
<td>+82%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Family Decline (%)</td>
<td>109 (51%)</td>
<td>106 (42%)</td>
<td>- 9%</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Donors lost due to</td>
<td>39</td>
<td>5</td>
<td>- 87%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>cardiovascular collapse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medically unsuitable</td>
<td>9</td>
<td>40</td>
<td>+ 344%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Organs recovered</td>
<td>217</td>
<td>370</td>
<td>+ 71%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*J Trauma. 2005;58:991–994.*
Aggressive Donor Management

Salim et al. J Trauma, 2005;58:991-994

- Aggressive Donor Management

↑153 organs over 3 years
New Terminology

- Catastrophic Brain Injury Guidelines
  - Goal – to maintain hemodynamic stability in patients with devastating brain injury
Organ Donor Timeline

1. Injury

2. 1st Brain death

3. 2nd Brain Death

4. Family consent

5. OPO Management

6. CVC

7. ADM

8. Organ Retrieval
Organ Donor Timeline

- Injury
- 1\textsuperscript{st} Brain death
- 2\textsuperscript{nd} Brain Death
- Family consent
- OPO Management
- CVC
- Organ Retrieval
- CBIG
Early identification of potential organ donor

ICU admission and management by dedicated ICU team

1. Pulmonary artery catheterization to monitor hemodynamic status and perfusion
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MAP < 70
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- Supportive Care

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Coagulopathy
- Aggressive correction (FFP, cryoprecipitate, Factor VII utilization)

SIADH
- Salt replacement with hypertonic saline, fluid restriction when appropriate
Donor Management Goals

Creating a checklist that anyone can follow......
<table>
<thead>
<tr>
<th>Critical Care Endpoint</th>
<th>DMG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mean Arterial Pressure (MAP)</td>
<td>60 – 100 mmHg</td>
</tr>
<tr>
<td>2. Central Venous Pressure (CVP)</td>
<td>4 – 10 mmHg</td>
</tr>
<tr>
<td>3. Ejection Fraction (EF)</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>4. Vasopressor use</td>
<td>≤ 1 and low dose</td>
</tr>
<tr>
<td>5. Arterial Blood Gas pH</td>
<td>7.3 – 7.45</td>
</tr>
<tr>
<td>6. PaO2:FiO2 (P:F)</td>
<td>&gt; 300 on PEEP = 5</td>
</tr>
<tr>
<td>7. Serum Na</td>
<td>135 – 160 mEq/L</td>
</tr>
<tr>
<td>8. Blood Glucose</td>
<td>&lt; 150 mg/dL</td>
</tr>
<tr>
<td>9. Hemoglobin (Hb)</td>
<td>&gt; 10 mg/dL</td>
</tr>
<tr>
<td>10. Urine Output (averaged over 4 hours)</td>
<td>1-3 cc/kg/hr</td>
</tr>
</tbody>
</table>
Achieving Donor Management Goals Before Deceased Donor Procurement Is Associated With More Organs Transplanted Per Donor

Darren J. Malinoski, MD, Michael C. Daly, MSc, Madhukar S. Patel, ScM, Chrystal Oley-Graybill, Clarence E. Foster III, MD, and Ali Salim, MD

**TABLE 2. Impact of DMGs on Organ Yield**

<table>
<thead>
<tr>
<th></th>
<th>DMGs Met</th>
<th>DMGs Not Met</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>% SCDs with ≥4 OTPD</td>
<td>70.1%</td>
<td>38.7%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mean OTPD ± SD</td>
<td>4.35 ± 1.61</td>
<td>3.32 ± 1.56</td>
<td>&lt;0.001†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transplanted</th>
<th>DMGs Met</th>
<th>DMGs Not Met</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right lung</td>
<td>37.1%</td>
<td>14.3%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Left lung</td>
<td>36.1%</td>
<td>14.3%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Heart</td>
<td>56.7%</td>
<td>30.5%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Liver</td>
<td>93.8%</td>
<td>81.6%</td>
<td>0.005*</td>
</tr>
<tr>
<td>Pancreas</td>
<td>40.2%</td>
<td>24.7%</td>
<td>0.005*</td>
</tr>
<tr>
<td>Right kidney</td>
<td>95.9%</td>
<td>87.4%</td>
<td>0.021*</td>
</tr>
<tr>
<td>Left kidney</td>
<td>94.8%</td>
<td>88.8%</td>
<td>0.088*</td>
</tr>
<tr>
<td>Intestine</td>
<td>2.1%</td>
<td>1.3%</td>
<td>0.641‡</td>
</tr>
</tbody>
</table>
Number of DMGs achieved

- ≤ 4
- 5
- 6
- 7
- 8
- ≥ 9
Outline

- Types of Donors
- Declaration of Brain Death
- Critical Care Management
Types of Donors
- Living, Deceased (DCD, DBD)

Declaration of Brain Death
- Protocols need to be in place

Critical Care Management
- Management of catastrophic brain injuries