Organ procurement

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Organ procurement

• Team structure and logistics
• Technical aspects (DBD, DCD)
• Organ Evaluation during procurement
• Organ preservation during transport
• Novel preservation technologies
Team structure for organ procurement

- Lead abdominal surgeon (fully trained in all aspects of abdominal retrieval)
- Assistant surgeon
- Theatre nurse
- Theatre practitioner (responsible for organ perfusion)

- Donor case notes for relevant history
- Brain death tests documentation (if applicable)
- Consent for donation and for specific organs to be retrieved
- Blood group (there must be clear documentation)
- Donor data, including haematology and biochemistry tests, microbiological results, and the amount of inotropic and ventilatory support, blood gases and chest x-ray (for cardiothoracic organs).
Technical variations in DBD procurement

• Warm vs cold phase dissection
• Single (aortic) vs Dual (aortic + portal vein) perfusion
• In situ vs ex situ liver splitting
• Separate vs en-bloc liver pancreas procurement
Multi-organ DBD retrieval

- Full midline exposure
- Thoraco-laparotomy

- Divide round and falciform ligaments
- Full laparotomy
- Divide adhesions to the liver
- Visceral mobilisation to expose retroperitoneum

• Sling lower end aorta
• Sling SMA at origin
• Sternotomy
Technical aspects

- Divide left triangular ligament

• Check for aberrant arterial anatomy
• Divide CBD

• Flush gallbladder until effluent is clear
• Sling GDA

• +/- Sling Splenic artery

• Pancreas inspection
• (Dissect aorta below the diaphragm /clamp)
• Give heparin (30,000 units)
• Cannulate aorta (usually 22 Fr)
• Co-ordinate with CT team
Portal cannulation for dual perfusion

• How?
  • IMV cannulation (not when pancreas is retrieved)
  • SMV cannulation (not when pancreas is retrieved)
  • Direct portal vein cannulation (preferred as avoids pancreas congestion)

• When?
  • Extended criteria DBD
  • DCD
• X-clamp

• TIP: Pull liver down and divide IVC. Divide IVC supra-hepatically for better drainage.
• Perfuse until clear fluid (3-4 litres) + intra-abdominal ice
En-bloc technique

Divide IVC above renal veins
(divide LRV flush with IVC)

Divide aorta below the origin of SMA
(! renal arteries)
En-bloc technique

• Divide IVC above renal veins

• Divide aorta below the origin of SMA (renal arteries)

• Mobilise tail of pancreas and spleen
• Divide IVC above renal veins
• Divide aorta below the origin of SMA (! renal arteries)
• Mobilise tail of pancreas and spleen
• Divide supra-hepatic IVC
• Divide supra-coeliac aorta

• Divide IVC above renal veins
• Divide aorta below the origin of SMA (renal arteries)
• Mobilise tail of pancreas and spleen
• Divide supra-hepatic IVC and divide supra-coeliac aorta
• Staple above pilorus and distally jejunum (mobilise Treitz ligament)
• Divide IVC above renal veins
• Divide aorta below the origin of SMA (! renal arteries)
• Mobilise tail of pancreas and spleen
• Divide supra-hepatic IVC and divide supra-coeliac aorta
• Staple above pilorus and distally jejunum (mobilise Treitz ligament)
• Staple SB mesentery
Bench separation for the liver-pancreas block
Kidney removal

• Incise posterior aortic wall between the lumbar arteries.
  • Avoid damaging a potential retro-aortic left renal vein

• Mobilise the posterior aspect of the right kidney medially and dissect on the para-spinal muscle, completely detaching the kidney and leaving only the ureter connected.

• The ureter is dissected with peri-ureteric tissue and divided below the level of the pelvic brim.

• The left kidney is dissected in a similar manner.
Cold perfusion

<table>
<thead>
<tr>
<th>Solution</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>In situ UW</td>
<td>3-4 L (100-150 mm Hg pressure)</td>
</tr>
<tr>
<td>Ex situ UW</td>
<td>CBD - 100-200 mls</td>
</tr>
<tr>
<td></td>
<td>Artery – 500 mls</td>
</tr>
<tr>
<td></td>
<td>PV – 1 L</td>
</tr>
</tbody>
</table>
Packing / transport

• Organs submerged in cold UW
• No ice in direct contact with the organs
• Triple bag
• Suitable sized cold-box
• Iliac vessels (artery and vein separately) - saline filled pots
• Lymph nodes - saline filled pots
# DCD categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Alternative categorisation</th>
<th>Status of potential donor</th>
<th>Hospital department</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Uncontrolled</td>
<td>Dead upon arrival</td>
<td>Accident and Emergency</td>
</tr>
<tr>
<td>II</td>
<td>Uncontrolled</td>
<td>Resuscitation attempted without success</td>
<td>Accident and Emergency</td>
</tr>
<tr>
<td>III</td>
<td>Controlled</td>
<td>Awaiting cardiac arrest</td>
<td>Intensive care</td>
</tr>
<tr>
<td>IV</td>
<td>Controlled</td>
<td>Cardiac arrest while brain dead</td>
<td>Intensive care</td>
</tr>
</tbody>
</table>
DCD pathway

Withdrawal of Treatment [WOT]

- Systolic BP < 50 mmHg
  - Asystole
  - PLE
  - Obligatory 5 minutes stand-off
  - Patient on-table
  - Knife to Skin
  - Aortic perfusion
  - Portal perfusion

Withdrawal time
- Liver - 60min
- Pancreas – 60min
- Kidneys – 3-4hrs

Donor Functional warm Ischaemia time (fWIT)
- Liver - 30min
- Pancreas 30 min
- Kidneys 60 min
Definition of ischemic times

• **Withdrawal time (agonal phase):** the time from WLST to circulatory arrest.

• **Warm ischemia time, primary (asystolic time):** the time from circulatory arrest to *in situ* perfusion.

• **Functional warm ischemia time (FWIT):** the time between the first episode of significant hypoperfusion and *in situ* perfusion.
  - Systolic BP ≤ 50 or 60 mmHg (widely accepted)

• **Total warm ischemia:** withdrawal time + warm ischemia time.
Ideal DCD?

Ideal DCD liver parameters include:

- Age < 50 years
- DWIT < 20 min
- Cold ischaemic time < 8 hours
- Minimal steatosis
(Modified) super rapid technique

Set up prior to starting procedure

1. (Thoraco)-laparotomy
2. Aortic cannulation
3. Venting through abdominal IVC
4. Thoracotomy/Aortic cross clamp/Venting in the chest
5. Topical cooling
6. **Portal cannulation**
7. Bile flush
8. Cold phase dissection
Changes in DCD retrieval

• DCD II and DCD III

• Normothermic Regional Perfusion (NRP)
  • Abdominal regional perfusion circuit
  • Oxygenated blood
  • Normothermia (37°C)

• Heart retrieval
What is NRP?
Rationale for NRP in DCD donors

- May improve tolerance to warm ischaemia
- Reduce susceptibility to cold ischaemia
- Maintain and perhaps improve organ quality
- Restore ATP
NRP in practice

- Vascular cannulation
  - Abdominal aorta
  - IVC

- Circuit connected
- Aorta Xclamped
- NRP started
NRP technical variations

• Vascular cannulation
  • Femoral artery
  • Femoral vein

• Endo-aortic ballon (via contralateral femoral artery)

• Simultaneous introduction of prime solution and pre-medication in the circuit (whilst cannulating)
NRP allows for an objective dynamic organ assessment
Organ Utilisation with NRP

- **Kidney**
  - No NRP: 84%
  - NRP: 91%

- **Liver**
  - No NRP: 34%
  - NRP: 63%

- **Pancreas**
  - No NRP: 21%
  - NRP: 34%

Oniscu GC, et al In submission
NRP increases organ utilisation

Liver:
- Offered: 100
- Accepted (% offered): 95, 88, 59
- Retrieved (% offered): 91, 77, 49
- Transplanted (% offered): 83, 63, 34

Kidney:
- Offered: 100
- Accepted (% offered): 99, 95, 91
- Retrieved (% offered): 97, 93, 97
- Transplanted (% offered): 98, 89, 84

Pancreas:
- Offered: 100
- Accepted (% offered): 72, 66, 66
- Retrieved (% offered): 62, 50, 45
- Transplanted (% offered): 34, 32, 21

Oniscu GC, et al In submission
### DCD liver transplant clinical outcomes in UK

<table>
<thead>
<tr>
<th>Bile duct complications</th>
<th>NRP liver donors (n = 43)</th>
<th>Comparator cohort (n = 188)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary leak</td>
<td>3/43 (7%)</td>
<td>18/175 (10%)</td>
<td>0.7729</td>
</tr>
<tr>
<td>Anastomotic stricture</td>
<td>3/42 (7%)</td>
<td>46/171 (27%)</td>
<td>0.0069</td>
</tr>
<tr>
<td>Ischaemic cholangiopathy</td>
<td>0/42 (0%)</td>
<td>46/171 (27%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
NRP improves DCD kidney function

<table>
<thead>
<tr>
<th>Graft outcomes</th>
<th>NRP Kidney transplants (N=152)</th>
<th>Non NRP kidney transplants (N=5051)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-month graft failure* N(%)</td>
<td>6 (4%)</td>
<td>332 (7%)</td>
</tr>
<tr>
<td>Delayed Graft Function N(%)</td>
<td>48 (20.4%)</td>
<td>530 (28.7%)</td>
</tr>
<tr>
<td>Primary non-function N(%)</td>
<td>1 (0.4%)</td>
<td>48 (2.6%)</td>
</tr>
<tr>
<td>Mean eGFR at one year** (ml/min/1.73m²)</td>
<td>56.4</td>
<td>45.6</td>
</tr>
</tbody>
</table>

Oniscu et al in submission
Hypothermic machine perfusion?

Hypothermic Machine Perfusion in Liver Transplantation — A Randomized Trial

Van Rijn R et al NEJM 2021
Kidney hypothermic transportable perfusion devices
## HOPE – immunomodulatory effect?

### Oxygenated versus standard cold perfusion preservation in kidney transplantation (COMPARE): a randomised, double-blind, paired, phase 3 trial

Jochmans I et al. The Lancet 2020

<table>
<thead>
<tr>
<th>Primary endpoint†</th>
<th>HMPO$_2$ mean</th>
<th>HMP mean</th>
<th>Mean or risk difference*</th>
<th>p value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary comparison (n=83)</td>
<td>50.5 (19.3)</td>
<td>46.7 (17.1)</td>
<td>3.7 (-1.0 to 8.4)</td>
<td>0.12</td>
</tr>
<tr>
<td>Sensitivity analysis (n=106)</td>
<td>47.6 (20.1)</td>
<td>42.6 (20.3)</td>
<td>5.0 (0.4 to 9.7)</td>
<td>0.035</td>
</tr>
</tbody>
</table>

### Secondary endpoints

<table>
<thead>
<tr>
<th>Secondary endpoints</th>
<th>HMPO$_2$ mean</th>
<th>HMP mean</th>
<th>Mean or risk difference*</th>
<th>p value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary non-function (n=106)</td>
<td>3 (3%)</td>
<td>5 (5%)</td>
<td>-2 (-7 to 3)</td>
<td>0.48</td>
</tr>
<tr>
<td>Delayed graft function (n=106)</td>
<td>38 (36%)</td>
<td>38 (36%)</td>
<td>0 (-14 to 14)</td>
<td>0.99</td>
</tr>
<tr>
<td>Functional delayed graft function (n=106)</td>
<td>76 (72%)</td>
<td>76 (72%)</td>
<td>0 (-13 to 11)</td>
<td>0.99</td>
</tr>
<tr>
<td>Acute rejection shown by a biopsy (n=106)</td>
<td>15 (14%)</td>
<td>27 (26%)</td>
<td>-11 (-22 to -0.01)</td>
<td>0.040</td>
</tr>
</tbody>
</table>
A randomized trial of normothermic preservation in liver transplantation

David Nasrallah, Constantin C. Coussios, … for the Consortium for Organ Preservation in Europe

Schneebberger S. Nature 2018; doi: 10.1038/d41586-018-04458-w


doi:10.1111/ajt13708
A randomized trial of normothermic preservation in liver transplantation

David Nasralla, Constantin C. Coutsios, [...] for the Consortium for Organ Preservation in Europe

<table>
<thead>
<tr>
<th></th>
<th>NMP (n=121)</th>
<th>SCS (n=101)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discard rates</td>
<td>16 (11.7%)</td>
<td>32 (24.1%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Total preservation time (min)</td>
<td>714 (258-1527)</td>
<td>465 (223-967)</td>
<td>0.0000</td>
</tr>
<tr>
<td>Machine perfusion time</td>
<td>547.5 (85-1388)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Increasing organ utilisation
In situ DBD Liver assessment

<table>
<thead>
<tr>
<th></th>
<th>Normal graft</th>
<th>Mild steatosis</th>
<th>Moderate steatosis</th>
<th>Severe steatosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colour</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Margins</strong></td>
<td>Sharp</td>
<td>Sharp/mild blunting</td>
<td>Blunting right lobe/left lobe</td>
<td>Blunt</td>
</tr>
<tr>
<td><strong>Consistency</strong></td>
<td>Soft</td>
<td>Slightly indurated</td>
<td>Heavy</td>
<td>Heavy</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

DCD Liver assessment

- History
- Age
- BMI
- FWIT
- Agonal time
- Quality of perfusion
- Surgeon’s experience

<table>
<thead>
<tr>
<th></th>
<th>Standard cDCD donor</th>
<th>Expanded cDCD donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>&lt;50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>&lt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>&lt; 5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>WIT (min)</td>
<td>≤ 20</td>
<td>20-30</td>
</tr>
<tr>
<td>CIT (hours)</td>
<td>≤ 8</td>
<td>&gt;8-12</td>
</tr>
<tr>
<td>Steatosis (%)</td>
<td>≤15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Recommendation</td>
<td>All potential liver donors fulfilling these criteria should be used</td>
<td>These grafts should be used selectively</td>
</tr>
</tbody>
</table>

DCD pancreas assessment

- History
- Age
- BMI
- FWIT
- Agonal time
- Quality of perfusion
- ....Surgeon’s experience

<table>
<thead>
<tr>
<th></th>
<th>Standard cDCD</th>
<th>Expanded cDCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>&lt;45</td>
<td>45-60</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>&lt;28</td>
<td>28-30</td>
</tr>
<tr>
<td>WIT (min)</td>
<td>≤ 30</td>
<td>&gt;30</td>
</tr>
<tr>
<td>CIT (hr)</td>
<td>≤ 9</td>
<td>&gt;9</td>
</tr>
<tr>
<td>Steatosis</td>
<td>None</td>
<td>Mild-moderate</td>
</tr>
<tr>
<td>Recommendation</td>
<td>All potential pancreas donors fulfilling these criteria should be used</td>
<td>These grafts should be used selectively</td>
</tr>
</tbody>
</table>

Poor perfusion (Grade 3)
Kidney with a global purple/black appearance

Excellent perfusion (Grade 1)
Kidney with a global pink appearance

Moderate perfusion (Grade 2)
Kidney with a patchy appearance

Poor perfusion (Grade 3)
Kidney with a global purple/black appearance

Ex situ kidney assessment

Macroscopic Appearance

- Correlation with biopsy
- Biomarkers
- Pump parameters
- Functional assays
### Graft assessment

<table>
<thead>
<tr>
<th>Score</th>
<th>Macroscopic assessment</th>
<th>Renal blood flow (ml per min per 100 g)</th>
<th>Total urine output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grade I: excellent perfusion (global pink appearance)</td>
<td>Threshold ≥ 50</td>
<td>Threshold ≥ 43</td>
</tr>
<tr>
<td>2</td>
<td>Grade II: moderate perfusion (patchy appearance)</td>
<td>Threshold &lt; 50</td>
<td>Threshold &lt; 43</td>
</tr>
<tr>
<td>3</td>
<td>Grade III: poor perfusion (global mottled and purple/black appearance)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Renal blood flow (ml per min per 100 g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Total urine output</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Severity of Injury**

- Score 1: Mild injury
- Score 2: Moderate injury
- Score 3: Severe injury
- Score 4: Critical injury
- Score 5: Severe complication
Difficult anatomy- solutions

- Aberrant RHA
- Kocherise duodenum +/- sling SMA

**En bloc retrieval**

- Extra-pancreatic + pancreas retrieval
- PD from RHA
- Intra-pancreatic
- No pancreas retrieval
- Pancreas retrieval

- Follow RHA and divide SMA above its insertion
- Aortic patch with Coeliac and SMA

- Discuss with liver surgeon and pancreas surgeon
- Divide HA above PD insertion
- Aortic patch with coeliac (SMA to panc)
- Abandon pancreas retrieval (if compromising liver retrieval)

Summary

• Keep up to date with current developments
• Work as a professional team
• Know
  • your anatomy
  • your limitations
  • the pitfalls of the operation
• Do no damage
• Communicate with recipient team
• Practice makes perfect...