Transfusion support in Transplantation

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Objectives

• UofA transplant programs
  – What we do and why?

• HLA and ABO incompatible transplants
  – Strategies for antibody removal
  – Transfusion support
Transfusion products used to support

- IVIG high dose (2g/Kg) and low dose (0.1g/kg)
- CMV Ig, HBIG
- Packed cells
- platelets
- Plasma
- Albumin
## Transplants UofA 2014

<table>
<thead>
<tr>
<th>Organ</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney</td>
<td>74</td>
</tr>
<tr>
<td>Kidney Pancreas</td>
<td>7</td>
</tr>
<tr>
<td>Pancreas</td>
<td>2</td>
</tr>
<tr>
<td>Heart</td>
<td>24</td>
</tr>
<tr>
<td>Lung</td>
<td>44</td>
</tr>
<tr>
<td>Heart/Lung</td>
<td>2</td>
</tr>
<tr>
<td>Liver</td>
<td>66</td>
</tr>
<tr>
<td>Small bowel</td>
<td>0</td>
</tr>
<tr>
<td>islet</td>
<td>54</td>
</tr>
</tbody>
</table>

**Total 284 procedures**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>ALL PATIENTS ON DIALYSIS (N=228,552)</th>
<th>PATIENTS ON THE WAITING LIST (N=46,164)</th>
<th>RECIPIENTS OF CADAVERIC TRANSPLANTS (N=23,275)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RATE/100 PATIENT-YR</td>
<td>NO. OF DEATHS</td>
<td>RATE/100 PATIENT-YR</td>
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<tr>
<td>All patients</td>
<td>16.1</td>
<td>84,713</td>
<td>6.3</td>
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<tr>
<td>Age*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–19 yr</td>
<td>3.6</td>
<td>257</td>
<td>2.2</td>
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<tr>
<td>20–39 yr</td>
<td>8.6</td>
<td>7,499</td>
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<tr>
<td>40–59 yr</td>
<td>13.3</td>
<td>30,935</td>
<td>6.5</td>
</tr>
<tr>
<td>≥60 yr</td>
<td>23.2</td>
<td>46,022</td>
<td>10.0</td>
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<tr>
<td>Sex</td>
<td></td>
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<tr>
<td>Male</td>
<td>16.2</td>
<td>45,366</td>
<td>6.3</td>
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<tr>
<td>Female</td>
<td>16.1</td>
<td>39,347</td>
<td>6.3</td>
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<tr>
<td>Race</td>
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<td></td>
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<tr>
<td>White</td>
<td>19.3</td>
<td>55,786</td>
<td>7.5</td>
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<tr>
<td>Black</td>
<td>12.4</td>
<td>25,733</td>
<td>4.8</td>
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<tr>
<td>Asian</td>
<td>9.9</td>
<td>1,783</td>
<td>3.0</td>
</tr>
<tr>
<td>Native American</td>
<td>13.3</td>
<td>1,411</td>
<td>6.5</td>
</tr>
<tr>
<td>Cause of end-stage renal disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>19.9</td>
<td>44,916</td>
<td>10.8</td>
</tr>
<tr>
<td>Other</td>
<td>13.3</td>
<td>39,797</td>
<td>4.3</td>
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</table>

*The ages shown are the age at the time of the first treatment for end-stage renal disease in the group of all patients on dialysis (age limit, 69 years), the age at the time of initial placement on the waiting list for patients on the waiting list, and the age at transplantation for transplant recipients.
<table>
<thead>
<tr>
<th>GROUP</th>
<th>RELATIVE RISK 18 Mo after Transplantation (95% CI)†</th>
<th>P VALUE</th>
<th>TIME AT WHICH RISK OF DEATH EQUALS THAT IN REFERENCE GROUP</th>
<th>TIME AT WHICH LIKELIHOOD OF SURVIVAL EQUALS THAT IN REFERENCE GROUP</th>
<th>PROJECTED YEARS OF LIFE (in reference group) without Transplantation†‡</th>
<th>PROJECTED YEARS OF LIFE WITH Transplantation‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All recipients of first cadaveric transplants</td>
<td>0.32 (0.30–0.35)</td>
<td>&lt;0.001</td>
<td>106</td>
<td>244</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–19 yr</td>
<td>0.33 (0.12–0.87)</td>
<td>0.03</td>
<td>3</td>
<td>5</td>
<td>26</td>
<td>39</td>
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<tr>
<td>20–39 yr</td>
<td>0.24 (0.20–0.29)</td>
<td>&lt;0.001</td>
<td>11</td>
<td>57</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>40–59 yr</td>
<td>0.33 (0.29–0.37)</td>
<td>&lt;0.001</td>
<td>95</td>
<td>251</td>
<td>11</td>
<td>22</td>
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<tr>
<td>60–74 yr</td>
<td>0.39 (0.33–0.47)</td>
<td>&lt;0.001</td>
<td>148</td>
<td>369</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.34 (0.30–0.38)</td>
<td>&lt;0.001</td>
<td>110</td>
<td>255</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>0.30 (0.26–0.34)</td>
<td>&lt;0.001</td>
<td>94</td>
<td>220</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native American</td>
<td>0.50 (0.27–0.96)</td>
<td>0.04</td>
<td>123</td>
<td>304</td>
<td>9</td>
<td>14</td>
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<tr>
<td>Asian</td>
<td>0.43 (0.25–0.75)</td>
<td>0.003</td>
<td>161</td>
<td>673</td>
<td>15</td>
<td>23</td>
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<tr>
<td>Black</td>
<td>0.52 (0.44–0.62)</td>
<td>&lt;0.001</td>
<td>109</td>
<td>305</td>
<td>13</td>
<td>19</td>
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<tr>
<td>White</td>
<td>0.28 (0.25–0.30)</td>
<td>&lt;0.001</td>
<td>100</td>
<td>220</td>
<td>9</td>
<td>19</td>
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<tr>
<td>Cause of end-stage renal disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.27 (0.24–0.30)</td>
<td>&lt;0.001</td>
<td>57</td>
<td>146</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>0.39 (0.31–0.48)</td>
<td>&lt;0.001</td>
<td>130</td>
<td>360</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Other</td>
<td>0.38 (0.33–0.43)</td>
<td>&lt;0.001</td>
<td>137</td>
<td>353</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Age and diabetes status</td>
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</tr>
<tr>
<td>20–39 yr, no diabetes</td>
<td>0.38 (0.28–0.50)</td>
<td>&lt;0.001</td>
<td>14</td>
<td>220</td>
<td>20</td>
<td>31</td>
</tr>
<tr>
<td>20–39 yr, diabetes</td>
<td>0.18 (0.14–0.23)</td>
<td>&lt;0.001</td>
<td>10</td>
<td>35</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>40–59 yr, no diabetes</td>
<td>0.38 (0.33–0.43)</td>
<td>&lt;0.001</td>
<td>126</td>
<td>356</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>40–59 yr, diabetes</td>
<td>0.27 (0.23–0.32)</td>
<td>&lt;0.001</td>
<td>66</td>
<td>181</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>60–74 yr, no diabetes</td>
<td>0.37 (0.30–0.46)</td>
<td>&lt;0.001</td>
<td>159</td>
<td>442</td>
<td>7</td>
<td>12</td>
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<tr>
<td>60–74 yr, diabetes</td>
<td>0.46 (0.34–0.61)</td>
<td>&lt;0.001</td>
<td>89</td>
<td>247</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Wolfe RA NEJM 1999
Optimization of Transplant Outcomes

• HLA compatible
• ABO compatible
• Medically stable donor and recipient
# Death on Wait List Canada

<table>
<thead>
<tr>
<th>year</th>
<th>Liver</th>
<th>Kidney</th>
<th>Lung</th>
<th>Heart</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>74</td>
<td>82</td>
<td>51</td>
<td>22</td>
<td>239</td>
</tr>
<tr>
<td>2011</td>
<td>93</td>
<td>80</td>
<td>67</td>
<td>25</td>
<td>265</td>
</tr>
<tr>
<td>2012</td>
<td>62</td>
<td>84</td>
<td>69</td>
<td>15</td>
<td>230</td>
</tr>
</tbody>
</table>

CORR 2012 report
• Cant always wait for perfect donor
• Candidates may have multiple medical issues
  – Diabetes
  – Anticoagulation
  – Liver disease
  – CKD
• Sometimes have to cross immunological barriers
  – ABO
  – HLA
ABOi

- Traditionally ABOi was a contraindication to transplant
- ABOi large experience from Japan-Living donors
- Over the past decade as transplant programs become comfortable with desensitization ABOi LD are commonly performed.
- For deceased donors not usually performed in kidneys
- ABOi pediatric heart transplant pioneered by Dr West now widely adopted
Ways to remove anti-A/B antibodies

**Specific**
Removal of anti-A/anti-B antibodies only
Glycosorb®-ABO columns

**Unspecific**
Removal of IgG & other proteins
Protein columns

**Unspecific**
Removal of plasma (all components)
Plasma exchange / DFPP
Montgomery R et al Transplantation 2012
HLA INCOMPATIBLE
Fig. 1. Schematic summary of an alloimmune response. Exposure to foreign allo-antigens via pregnancy, transfusion, or previous transplantation provides a source of stimulation to produce allo-antibodies and cytotoxic T cells.
HLA antibody testing

- All transplant candidates have detailed antibody testing and identification
- Any antigen that the program wants to avoid in a donor is defined “unacceptable (UA)
- UA are entered into donor antigen registry which calculates % of donors with this antigen(s) - cPRA
Canadian cPRA Calculator

The Canadian cPRA calculator is a component of the Canadian Transplant Registry (CTR), a web-based application used by the transplant community, to estimate the percentage of Canadian deceased organ donors with whom a transplant candidate may be incompatible.

This calculator uses the same formula and data as the CTR. It produces a value by comparing the unacceptable antigens entered below. If you are a transplant candidate, and have questions regarding the value generated by this calculator, please contact your transplant physician or coordinator.

Attention: The actual cPRA value assigned to a transplant candidate is calculated by the CTR based on the unacceptable antigens that are entered by the laboratory at the transplant candidate’s transplant centre. The value produced by the cPRA calculator on this web-site is for your informational use only.

Select Blood Groups:
- O
- A
- B
- AB

Select Region:
- Alberta
- Atlantic-Canada
- British-Columbia
- Manitoba
- Ontario
- Saskatchewan
- Quebec

Check all A unacceptable antigens:
- 1
- 2
- 3
- 11
- 23
- 24
- 25
- 26
- 29
- 30
- 31
- 32
- 33
- 24
- 36
- 43

Check all B unacceptable antigens:
- 7
- 8
- 13
- 18
- 27
- 35
- 37
- 38
- 39
- 41
- 42
- 44
- 45
- 46
- 47
- 48

Check all C unacceptable antigens:
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- 63
- 64

Check all Dw unacceptable antigens:
- 4
- 6
- N/A

Check all Cw unacceptable antigens:
- 1
- 2
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 12
- 14
- 15
- 16
- 17
- 18

Check all DR unacceptable antigens:
- 1
- 0103
- 4
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18

Check all DR51/102/23 unacceptable antigens:
- 51
- 52
- 53

Check all DQ8 unacceptable antigens:
- 1
- 4
- 5
- 6
- 7
- 8
- 9

[Image of calculator interface]
Feingold et al

Annual probability of death after HTx with +DSXM (median post transplant survival)

Probability of a positive DSXM (TAKE group)

WAIT favored

TAKE favored
5.4 (b) cPRA of Candidates and Transplant Recipients, n(%)  

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1%-79%</th>
<th>80%-94%</th>
<th>95%-96%</th>
<th>97%+</th>
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</thead>
<tbody>
<tr>
<td>Total Transplanted</td>
<td>49(22)</td>
<td>92(42)</td>
<td>42(19)</td>
<td>12(6)</td>
<td>23(11)</td>
</tr>
<tr>
<td>Not Transplanted</td>
<td>45(16)</td>
<td>69(25)</td>
<td>13(5)</td>
<td>11(4)</td>
<td>135(50)</td>
</tr>
<tr>
<td>Total Candidates in cPRA Group</td>
<td>94(19)</td>
<td>161(33)</td>
<td>55(11)</td>
<td>23(5)</td>
<td>158(32)</td>
</tr>
<tr>
<td>% of cPRA Group Transplanted</td>
<td>52%</td>
<td>56%</td>
<td>68%</td>
<td>50%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Candidates with cPRA ≥ 97% have increased in prevalence in the KPD registry and presently represent 53% of active candidates. Conversely, candidates with cPRA 95-96% have decreased in prevalence in the registry over time.
How can we predict outcome if DSA present?
1. Preexisting host antibodies are carried to kidney graft

2. Antibodies bind to antigens of renal capillaries and activate complement (C^−)
   - Capillary endothelial walls

3. Complement split products attract neutrophils, which release lytic enzymes
   - Enzymes

4. Neutrophil lytic enzymes destroy endothelial cells; platelets adhere to injured tissue, causing vascular blockage
   - Platelets
Polys in Peritubular capillaries, glomerulitis

C4d staining
AMR

• **Hyperacute** IgG rapid within minutes. Graft loss almost 100%, memory*

• **Acute accelerated** IgG, within hours or days, 30-70% graft loss, memory*

• **Late** >3months usually primary ie de novo

*(should not occur with sensitive crossmatching)*
## Graft loss associated with HLA antibodies

<table>
<thead>
<tr>
<th>Study</th>
<th>Class</th>
<th>DSA</th>
<th>Time of sample</th>
<th>Pre existing or de novo</th>
<th>Time of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everly</td>
<td>I, II I + II Mostly DQ</td>
<td>DSA</td>
<td>Post</td>
<td>De novo</td>
<td>Serial. 20% DSA at 5 years</td>
</tr>
<tr>
<td>Mao Q</td>
<td>Not reported</td>
<td>DSA</td>
<td>Post</td>
<td>Not tested in all</td>
<td>&gt;21.6 +/- 20.4 months</td>
</tr>
<tr>
<td>Campos</td>
<td>I + II and II</td>
<td>HLA</td>
<td>post</td>
<td>Not tested</td>
<td>Med 4.4 years</td>
</tr>
<tr>
<td>Hidalgo</td>
<td>I + II and II</td>
<td>DSA</td>
<td>Post</td>
<td>Pre 41%/de novo 59%</td>
<td>Med 5.6 years</td>
</tr>
<tr>
<td>Gaston</td>
<td>Not reported</td>
<td>DSA</td>
<td>Post</td>
<td>not reported</td>
<td>7.3+/-6 years</td>
</tr>
<tr>
<td>Wiebe</td>
<td>I, II and I+II</td>
<td>DSA</td>
<td>Post</td>
<td>De novo</td>
<td>Mean 4.6±3 years</td>
</tr>
</tbody>
</table>

Desensitization

Removal of antibody can be HLA or ABO
Table 2. Desensitization therapies [6]a

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Dose</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>(A, F) 1.5 volume exchanges</td>
<td>(A) 5 consecutive days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(B) 5 times, every other day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(C) 2–3 times/week until transplant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(D) 5 times, every other day, every 2–4 weeks</td>
</tr>
<tr>
<td>IVIG</td>
<td>(A, B) 2 g/kg IV divided over 2 days</td>
<td>(A) every 2–4 weeks</td>
</tr>
<tr>
<td></td>
<td>(C) 2–3 g/kg IV divided over 4 days</td>
<td>(D) every 2–4 weeks</td>
</tr>
<tr>
<td></td>
<td>(D) 0.1 mg/kg IV</td>
<td>(G) every 4 weeks</td>
</tr>
<tr>
<td></td>
<td>(E) 100 mg/kg IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(F) 20 g (of 10% IVIG)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(G) 150 g (of 10% IVIG) divided over 3 rounds</td>
<td></td>
</tr>
<tr>
<td>Rituximab</td>
<td>(A) 1 g IV</td>
<td>(A) weekly × 4</td>
</tr>
<tr>
<td></td>
<td>(C) 375 mg/m²</td>
<td>(C) × 2 doses</td>
</tr>
<tr>
<td></td>
<td>(G) 500 mg</td>
<td>(G) every 2 weeks</td>
</tr>
<tr>
<td>Cyclophosphamide</td>
<td>(used in the past)</td>
<td>(A) daily</td>
</tr>
<tr>
<td></td>
<td>(A) 1 mg/kg orally</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(C) 0.5 μg/m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(D) 1 mg/kg orally</td>
<td></td>
</tr>
</tbody>
</table>

A = UCLA; B = Stanford University; C = University of Maryland; D = University of Toronto; E = University of Wisconsin; F = Loyola University Chicago; G = University of Berlin.

*Choices to consider as desensitization therapies include IVIG infusion, PP, either alone or combined, Rituximab, and in very selected cases, splenectomy.
Goal of Plasmapheresis

- Removal of HLA or ABO antibodies
- Antibody Mediated Rejection AMR
- Targeted (donor identified) peri-transplant
  - LD can start several weeks prior to procedure
  - DD immediately pre and post transplant (HLA incompatible)
- Other strategies
  - High dose IVIG, rituximab, bortezomib
Antibody removal can be achieved by:

- Centrifugation and removal of plasma with return of cellular products with replacement fluid
- Removal with large bore hemafilter
- Immunoadsorption with filter
Fig. 1. Hypothetical depletion of whole body Ig levels by TPE after 1.5 PV exchanges performed every 2 days [13].
Fig. 1 PP/IVIG desensitization protocol. The protocol utilizes every other day plasmapheresis along with low-dose IVIG (100 mg/kg). The number of pre-transplant PP/IVIG treatments can be predicted from the starting donor reactive antibody titer. Several post-transplant PP/IVIG treatments are performed by protocol. PP/IVIG treatments are added as needed to reduce antibody levels to pre-transplant targets or to treat an episode of antibody mediated rejection. In selective high-risk cases, anti-CD20 is given the night before the transplant. In our experience, about 5% of +XM patients will require rescue splenectomy as part of the treatment for severe AMR.
Course of Rejection depends on the antibody response.
- Daily initially 3-5 days then q 2 days
- 1.5-2 volume plasma exchange
- May need plasma replacement if early post or daily treatments
- Albumin preferable
- HLA antibody monitoring can guide therapy
IVIG

• Used as low dose with plasmapheresis to replace IgG removed.

• High dose
  – Glotz
  – Jordan

Glotz D Transplantation 1993
Jordan S Transplantation 1998
Glotz D Am J Transplant 2002
IVIG

- **F(ab)_2 dependent**
  - Block cell receptors
  - Cell depletion - ADCC

- **Fc dependent**
  - Scavenge cytokines, Ab, anaphylatoxin
  - Expand Treg
  - Block activating R
  - Modulate dendritic cells
  - Modulate FcgR expression

Schwab I et al Nature Reviews 2013
Rituximab, PP, MP, Bortezomib

- Day 0 Rituximab
- Day 1 Plasmapheresis, MP 5mg/kg
- Day 1 bortezomib 1.3mg/m²

PP, MP, Bortezomib

- Day 4 Plasmapheresis, MP 5mg/kg
- Day 4 Bortezomib 1.3mg/m²

PP, MP, Bortezomib

- Day 8 Plasmapheresis, MP 5mg/kg
- Day 8 Bortezomib 1.3mg/m²

PP, MP Bortezomib

- Day 11 Plasmapheresis, MP 5mg/kg
- Day 11 Bortezomib 1.3mg/m²

plasmapheresis

- Day 14-16 Plasmapheresis

Walsh RC, *Transplantation* 2011;
<table>
<thead>
<tr>
<th>n</th>
<th>Treatment</th>
<th>DSA testing</th>
<th>DSA post treatment</th>
<th>outcome</th>
<th>Post treatment biopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billing</td>
<td>20</td>
<td>IVIG 1g/kg weekly x 4 Ritux 375mg/m2 x 1</td>
<td>Luminex</td>
<td>7/20 DSA negative</td>
<td>No change in proteinuria GFR slower decline</td>
</tr>
<tr>
<td>Waiser</td>
<td>19</td>
<td>PP/IVIG and either ritux 500mg x 1 or bortez 1.3mg/m2 x 4 doses</td>
<td>Luminex</td>
<td>Sustained decrease in DSA greater in bortez treated</td>
<td>GS 11% ritux vs 60% bortez at 18 months</td>
</tr>
<tr>
<td>Smith</td>
<td>31</td>
<td>14 ritix vs 17 no ritux</td>
<td>ELISA</td>
<td>No change in 92% controls and 64% ritux</td>
<td>Dichotomous response to ritux</td>
</tr>
<tr>
<td>Fehr</td>
<td>4</td>
<td>SM pulse, Rituximab 375mg/m2 x 1 dose and IVIG 0.4mg daily x 4</td>
<td>Luminex</td>
<td>2 decreased (1 was ? Pre treatment)</td>
<td>Stabilization of GFR at six months but mixed picture so steroids may have impacted initial creat response</td>
</tr>
</tbody>
</table>

Liver Transplant

- HLA antibodies can cause AMR in liver but risk is much lower and generally not a barrier to transplantation.
- High titre class I HLA antibodies may be refractory to platelet transfusions and may require class I matched platelets.
Infection

• Heavy immunosuppression increases risk of infection
• May need IVIG to treat
• CMV
• HBIG (liver tx)
• IVIG may rarely be used to treat BK nephropathy,
Summary

• Transplantation is a life saving treatment for organ failure
• Transplant recipients have multiple medical issues that may require transfusion support in the form of blood products.
• High immunological risk transplant require additional support with IVIG, plasma and albumin to desensitize to HLA and ABO antibodies.
• Success of transplantation is truly a team effort
• support from Laboratory medicine invaluable
  – HLA Laboratory
  – Transfusion Medicine
  – Therapeutic Drug monitoring (Chemistry)
  – And many others
Strategies-Treatment

• Remove antibody
  – Plasmapheresis
  – IVIG

• Reduce antibody production
  – Rituximab
  – Bortezomib
  – Thymoglobulin
  – alemtuzumab

• Reduce impact/injury of graft
  – Eculizumab
  – IVIG
  – Steroids