Experience with Pediatric En Bloc Transplantation – A 35 Year Experience

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Barriers To Use Of Small Kidneys

• Technical problems
  • Early thrombosis
  • Ureteral leaks
• Hyperfiltration
• Delayed graft function
• Long-Term function
History Of En Bloc Transplantation

- Classic work of Carrel in 1908
- Single case report in 1969
- First large series in 1972 – Meakins

Alexis Carrel
Increasing The Donor Pool

- The number of patients has almost doubled since 2002 (now over 100,000)
- For patients awaiting kidney transplants only 48% will ever receive one
- 30% of patients have been waiting more than 6 years
- The best use of donors at extremes of age may be a way to help impact this problem
- There are 1 Million nephrons present in each kidney by 36 weeks of gestation
KDPI

- Introduced in order to predict quality of donors
- Very misleading for dual transplants (either pediatric en bloc or adult dual)
- Does not adequately evaluate the cumulative impact of reduced donor height, weight and age as it applies to en bloc transplants
  - Consequently the KDPI is falsely elevated – possibly discouraging the use of these kidneys
Recovery Issues

- Damage to renal vessels during multi-organ retrieval
  - Superior mesenteric artery in proximity to renal arteries in small donors
    - Arterial cap can be used if there is not total transection
  - Supra renal vena cava shortened with ellipse of tissue preventing closure in a single suture line
    - Almost always reparable by use of venous cap retrieved from excess caval or iliac vessels
- “Ureteral stripping” is often over estimated but if it has occurred may eliminate the use of this donor
UNOS Data

• Analyzed by Dharnidarka (1987-2004)
  • Compared 2160 en bloc transplants to 116,647 single transplants
    • DGF 23% single En bloc 17%
    • Superior long term function with en bloc transplants
Kayler (1997-2007)
Recovery Factors
(Donors <21 kgs discards)

• Single most important factor was vascular damage
  • 55% of liver donors recovered en bloc
  • 40% of intestinal donors
• Decreased donor weight was more predictive of non-recovery along with increasing creatinine
• Outcomes were worse with single kidney transplant than en bloc suggesting donors of this size should always use en bloc
Figure 1: Disposition of kidneys procured from small pediatric donors 1997-2007.

American Journal of Transplantation 2009; 9: 210-216
No correlation between donor weight and graft loss or surgical complication

Source: Hiramoto et al.
Bresnahan BA – et al Transplantation 2001

- 5% thrombosis rate in transplants from donors 12-17 years of age
- 10% thrombosis rate in transplants from donors less than 5 years of age

- Inferior outcomes with single grafts from donors greater than 15 kilograms compared to using dual en bloc kidneys from donors less than 5 years of age.
- Inferior outcomes with re-transplantation and those with a BMI greater than 24, black recipients, and prolonged ischemic time.
Dharnidarka Survival Rate

- Survival rates with en bloc and single pediatric to adult recipients
- Donors less than 5 years old

<table>
<thead>
<tr>
<th></th>
<th>EB</th>
<th>Single</th>
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<tbody>
<tr>
<td>1 Year</td>
<td>85</td>
<td>81</td>
</tr>
<tr>
<td>3 Years</td>
<td>76</td>
<td>68</td>
</tr>
<tr>
<td>5 Years</td>
<td>71</td>
<td>67</td>
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Figure 8. Actuarial kidney graft survival rates of pediatric en bloc (PEB) and single kidney transplantation (KT) recipients from pediatric donors ≤ 5 years of age.

Source: Vol. 228, No. 4, April 2019 Rogers et al Age and Dual Kidney Transplant Pg.699
Kidney survival of single vs. en bloc

Figure 9. Actuarial death-censored kidney graft survival rates of pediatric en bloc (PEB) and single kidney transplantation (KT) recipients from pediatric donors ≤ 5 years of age.

Source: Vol. 228, No. 4, April 2019 Rogers et al Age and Dual Kidney Transplant Pg.699
Patient and graft survival single vs, en bloc (another study)

Source: Al-Shraideh Y et al. Kidney transplant from small pediatric donors
• Recipient size all had BMI of less than 30 (concerns for hyperfiltration which is hypertension, proteinuria, glomerulosclerosis)
  • Found higher creatinine in bigger recipients disappeared at one month
  • En bloc seemed able to adopt to increased workloads
  • No signs of hyperfiltration after post transplant weight gain as was seen with single adult transplants
Comparison of en bloc vs. dual adult kidneys

Figure 1. Actuarial patient survival rates of pediatric en bloc (PEB) and dual kidney transplant (DCT) recipients.

Figure 3. Actuarial death-censored kidney graft survival rates of pediatric en bloc (PEB) and dual kidney transplant (DCT) recipients.

Source: Vol. 228, No. 4, April 2019 Rogers et al Age and Dual Kidney Transplant Pg.697
Long-Term Results

- Dual en bloc kidney transplants comparable to those following living donor transplants (Reddy et al Transplantation 2006) (Sharma et al Transplantation 2011)

- Outcomes following single kidney transplants from pediatric donors are comparable to those with standard criteria donors and superior to those achieved following extended criteria donors (Sharma et al Transplantation 2013)
Pediatric en bloc vs. dual adult graft survival (actuarial)

Figure 2. Actuarial kidney graft survival rates of pediatric en bloc (PEB) and dual kidney transplant (DKT) recipients.

Source: Vol. 228, No. 4, April 2019 Rogers et al Age and Dual Kidney Transplant Pg.697
En Bloc Vs. Living Donor Transplant

**FIGURE 1.** Kaplan-Meier estimates for graft survivals for pediatric en bloc and living donor kidneys.

Source: Sureshkumar et al pg. 246-247
Literature Suggests

- Always use en bloc over single kidneys < 5 years, 10-15 kgs, 6 cm
- Better survival of en bloc vs. dual adult kidneys (marginal)
- En bloc clearance better than SCD’s with weight gain suggesting they will “handle the load” better
- En bloc equal to LRD’s in early comparison
Initial experience with 13 en bloc kidneys from 1982-1987

Better results when ATN not present
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Total Number of patients</strong></td>
<td><strong>106</strong></td>
</tr>
<tr>
<td><strong>Timeframe</strong></td>
<td><strong>1987-2019</strong></td>
</tr>
<tr>
<td><strong>Median age (range)</strong></td>
<td><strong>46 years (16.0 - 72.0)</strong></td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td><strong>61 (58%)</strong></td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td><strong>45 (42%)</strong></td>
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<tr>
<td><strong>Primary Diagnosis</strong></td>
<td></td>
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<tr>
<td>- Hypertensive Nephrosclerosis</td>
<td><strong>24 (23%)</strong></td>
</tr>
<tr>
<td>- Chronic glomerulonephritis</td>
<td><strong>16 (15%)</strong></td>
</tr>
<tr>
<td>- Polycystic kidneys</td>
<td><strong>12 (11%)</strong></td>
</tr>
<tr>
<td>- Diabetes Mellitus</td>
<td><strong>10 (9%)</strong></td>
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<tr>
<td>- Diabetes Mellitus</td>
<td><strong>8 (8%)</strong></td>
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<tr>
<td>- Systemic Lupus Erythematosus</td>
<td><strong>7 (7%)</strong></td>
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<tr>
<td>- Others</td>
<td><strong>29 (27%)</strong></td>
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Distribution of Primary Diagnosis (N=106)

- Hypertensive Nephrosclerosis: 23%
- Chronic glomerulonephritis: 27%
- Polycystic Kidneys: 9%
- Diabetes Mellitus - Type II: 8%
- Diabetes Mellitus - Type I: 7%
- Systemic Lupus Erythematosus: 11%
- Other: 15%
Unadjusted Allograft Survival Rates at 1, 3, and 5 years post-transplant (N=106)
Allograft Survival Rate

Unadjusted Allograft Survival Rates at 1, 3, and 5 years post-transplant (N=106)
<table>
<thead>
<tr>
<th>Description</th>
<th>Number (Percentage)</th>
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<tbody>
<tr>
<td>Overall (all cause) mortality as of 7/1/19</td>
<td>24 (23%)</td>
</tr>
<tr>
<td>Median length of survival (years) as of 7/1/2019</td>
<td>15 years</td>
</tr>
<tr>
<td>Organ failure (independent of mortality)</td>
<td>24 (23%)</td>
</tr>
<tr>
<td>Organ failure (including mortality)</td>
<td>42 (40%)</td>
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<tr>
<td>Median time to allograft failure</td>
<td>2.5 years or 6.3 years</td>
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Kaplan-Meier Patient Survival Curve (N=106)
Kaplan-Meier Allograft Survival Curve (N=106)

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
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<tbody>
<tr>
<td>106</td>
<td>24</td>
<td>82</td>
<td>77.36</td>
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Conclusion: There is no statistically significant difference in survival probability by gender.
Complications

- 4 graft thrombosis out of 106 transplants
- 3 ureteral complications 1 graft loss
- 7% rate of ATN
Allograft Failure

(years) n=24

• This cohort only includes patients who experienced organ failure as an independent event from death.
• Vena cava should be exposed in anatomical position
• Identification of gonadal and adrenal veins
• Extra vascular tissue created
• Segment of extra aorta and vena cava
• Opened segment to create cap
• Liberal flushing to identify lumbar, gonadal, and adrenal veins. Determine if caval “cap” is required.
• Aorta examined from posterior position
• Identification of lumbar arteries
• Supra renal cava to be closed
Separation of aorta and cava prior to closure
• Iliac vessels exposed
identification of anastomotic site on donor cava
- Preparation of spatulation incision
• Placement of suture at apex of spatulation prior to placement of kidneys into iliac fossa

• Right side kidneys oriented with left kidney lateral right medial. Allows arterial anastomosis lateral, vein medial, STRAIGHT COURSE
- Wide spatulation
• Straight course of blood flow with kidneys in iliac fossa. Vein about to be approximated.
• Venous anastomosis complete
- Blood flow restored
- Individual ureteral anastomosis
Suggestions For Choosing Donors and Recipients

- Donors:
  - Separate if greater than 25 pounds or 3 years
  - Kidneys should be approximately 6cm individually

- Recipients:
  - Weight between 25 and 30 BMI (better anatomical length for ureters)
  - No severe iliac occlusive disease
  - Good cardiac output
  - Would not exclude because of status of re-transplantation or high PRA
Summary

• Our experience over 35 years demonstrated excellent results using pediatric en bloc donors
• Careful preparation of donor kidneys is tantamount in success – in particular using autogenous tissue for repair of damaged vessels
• Selection of recipients with a BMI less then 30 and the absences of severe peripheral vascular disease is important
• Re-transplantation and high immunologic profile is not important
• Delayed graft function was not seen in our patient population