Novel Approaches to Organ Utilization and Allocation

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Disclosure

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Learning Objectives

• Participants will be able to:
  – summarize characteristics of kidneys at high probability of delay or discard
  – identify utilization challenges related to delays in kidney allocation
  – compare alternatives to sequential kidney allocation including simultaneous offers, skipping candidates unlikely to accept, and open offers to centers
Discard and delay - Kidney

- Under new KAS, the kidney discard rate is almost **60% for KDPI > 85%** and approximately **20% overall** (Stewart et al. 2017)
- Every post-recovery kidney decline increases the CIT
- Long delays can cause usable organs of marginal quality to be eventually discarded (Massie et al. 2010)
Why are kidneys delayed and underutilized?

- Candidates near the top of the waiting list become more selective, so non-ideal kidneys must be offered until they reach candidates with lower priority, and making a large number of offers takes time.
- Centers that are reluctant to take non-ideal kidneys are also reluctant to declare this fact by filtering out offers.
- Centers delay placements when they are slow to decline offers; worse with larger numbers of centers in play for placing a kidney.
- OPOs delay placements by making offers only post-recovery.
The Aggressive Center Phenotype: Center-level patterns in the utilization of sub-optimal kidneys, Garonzik-Wang et al. AJT 12: 400-8, 2012
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Blue</th>
<th>Green</th>
<th>Yellow</th>
<th>Orange</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score</td>
<td>3.7</td>
<td>6.3</td>
<td>5.8</td>
<td>5.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Wait-list Size</td>
<td>176</td>
<td>343</td>
<td>331</td>
<td>461</td>
<td>511</td>
</tr>
<tr>
<td>Organ Shortage Ratio</td>
<td>4.7</td>
<td>6.6</td>
<td>7.3</td>
<td>7.7</td>
<td>8.5</td>
</tr>
<tr>
<td>Wait time (yrs)</td>
<td>4.1</td>
<td>5.4</td>
<td>8.6</td>
<td>8.2</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center Type</th>
<th>1 Year Graft Survival</th>
<th>3 Year Graft Survival</th>
</tr>
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<tbody>
<tr>
<td>Aggressive Centers</td>
<td>87.7%</td>
<td>75.1%</td>
</tr>
<tr>
<td>Non-Aggressive Centers</td>
<td>91.5%</td>
<td>81.7%</td>
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</table>
Reduce geographic disparity

- Center aggressiveness is related to kidney shortage: zero aggressive centers found in single-center OPOs, regions with more shortage have more aggressive centers
- DSAs and regions eliminated from kidney allocation; replaced with a 250 mile circle
Center aggressiveness report cards

- Facilitate changes in practice by showing centers which types of non-ideal kidneys they are rejecting, and which other centers use those kidneys
Benefit calculators

• Show centers, at the point of offer, how much their particular candidate’s expected survival improves if they accept a particularly
Non-ideal kidneys (with higher KDPI) still give survival benefit

![Survival Benefit Estimator](image-url)
Save it from the trash: get it for free

• If 12 centers refuse a kidney, and then your center takes it, outcomes are not tracked in program-specific reports

• Kidneys at highest risk of delay or discard also exempted from program-specific reports
Centers scared to take non-ideal kidneys
The more centers refuse an offer, the less likely the next center will accept it.
The more centers refuse an offer, the less likely the next center will accept it.

So by 12 offers, the organ is pretty much going in the trash.
The more centers refuse an offer, the less likely the next center will accept it.

If you rescue it from the trash, why should it count in your PSRs?
The more centers refuse an offer, the less likely the next center will accept it.

1. Unlikely anyone else would have used it, so you’re not wasting the resource.
The more centers refuse an offer, the less likely the next center will accept it.

2. Unlikely there are enough organs of the same type for fair risk adjustment.
Proposal

• If at least 12 centers declined the organ before you accepted it, it’s yours for free
But what if the offer went to you early:

*We know which kidneys centers are scared to take*

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**Improving Distribution Efficiency of Hard-to-Place Deceased Donor Kidneys: Predicting Probability of Discard or Delay**

A. B. Massie\textsuperscript{a,b}, N. M. Desai\textsuperscript{a}, R. A. Montgomery\textsuperscript{a}, A. L. Singer\textsuperscript{a} and D. L. Segev\textsuperscript{a,b,*}

\textsuperscript{a}Department of Surgery, Johns Hopkins University School of Medicine, \textsuperscript{b}Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD

\textsuperscript{*}Corresponding author: Dorry L. Segev, dorry@jhmi.edu
PODD score
(Probability of Discard or Delay)

\[
\text{odds} = \exp(-2.052 + 0.256 \times I[\text{female}] + 0.775 \times I[\text{age} > 40] \times \frac{(\text{age} - 40)}{10} + 0.345 \times I[\text{bloodab}] - 0.092 \times I[\text{bmi}] + 0.090 \times I[\text{bmi} > 23] \times (\text{bmi} - 23) + 0.352 \times I[\text{cancer}] + 0.105 \times I[\text{smoking}] + 0.409 \times I[\text{hypertension}] + 0.197 \times I[\text{mi}] + 0.322 \times I[\text{diabetes}] + 0.309 \times I[\text{diabetes10y}] + 0.335 \times I[\text{insulin}] + 1.000 \times I[\text{dcd}] + 0.049 \times I[\text{cva}] - 0.196 \times I[\text{head}] + 2.212 \times I[\text{htlv}] + 0.097 \times I[\text{cmv}] + 0.309 \times I[\text{hbvcore}] + 2.533 \times I[\text{hbvcoresurface}] + 1.922 \times I[\text{hepc}] + 0.250 \times I[\text{cdc}] - 0.515 \times I[\text{pumped}] + 1.321 \times I[\text{scler20}] + 1.123 \times I[\text{creat}])
\]

\[
\text{PODD} = \frac{\text{odds}}{1 + \text{odds}}
\]
Most high PODD kidneys don't get used

- PODD C statistic for predicting discard (prospective validation): $0.88$

- We know which kidneys centers don't want
Save it from the trash: get it for free

• If at least **12** centers declined the organ before you accepted it, it’s yours for free

• If you’re one of the first 12 centers offered the kidney, and the PODD > **65%**, it’s yours for free
Are unwanted kidneys really that bad?

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All Cause Graft Failure

- PODD ≤ 0.65
- PODD > 0.65

aHR: 1.42 1.60 1.82
Are unwanted kidneys really that bad?

“I never thought it was such a bad little tree. It’s not bad at all, really. Maybe it just needs a little love.”

We need to direct them to the right recipients (and the right centers)
Accelerating kidney allocation: simultaneously expiring offers

- OPTN policy uses **sequential** expiration of offers
  - After a center becomes primary, when all higher-priority candidates have declined, then clock starts for that center to answer
  - In December 2017 these time limits were shortened to 1 hour/30 minutes, but still offers expire sequentially

- We propose to make **simultaneously expiring kidney offers in batches** to multiple centers, for kidneys offered at **regional** and **national** allocation levels
  - All centers in the batch must reply within 1 hour
A New Approach

to Organ Allocation

OFFER

FIRST BATCH, FINAL DECISION
CENTER #1
CENTER #2
CENTER #3

1 HOUR

AT LEAST ONE CENTER ACCEPTS

SECOND BATCH, FINAL DECISION
CENTER #4
CENTER #5
CENTER #6

1 HOUR

AT LEAST ONE CENTER ACCEPTS

THIRD BATCH, FINAL DECISION
CENTER #7
CENTER #8
CENTER #9

1 HOUR

KIDNEY PLACED

Offer

Provisional yes

Offer made to primary center

Accept

Decline

30 minutes

Offer made to center #2

Accept

Decline

Offer made to center #3

320miles

Decline

20miles
Accelerating allocation: Simulation

- Simulation based on Kidney-Pancreas Simulated Allocation Model (KPSAM) by SRTR
- Kidney is considered as discarded after 20h of placement
- We assumed that one hour delay decreased acceptance by 5%
  - There are no national data available about timing of offers, nor about incidence of post-recovery offers
  - OPTN does not report the time that a center received an offer, how long each center took to enter a final accept or decline decision, and do not even accurately reflect how many centers evaluated each organ offered
- We report the trade off between decreasing delay/discard and increasing offer screening burden with more centers per batch
<table>
<thead>
<tr>
<th>Batch</th>
<th>Ranking match list</th>
<th>Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Candidate 1</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Candidate 2</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Candidate 3</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Candidate 4</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Candidate 5</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Candidate 6</td>
<td>B</td>
</tr>
<tr>
<td>Second</td>
<td>Candidate 7</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Candidate 8</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Candidate 9</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Candidate 10</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>Candidate 11</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Candidate 12</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Candidate 13</td>
<td>G</td>
</tr>
<tr>
<td></td>
<td>Candidate 14</td>
<td>A</td>
</tr>
</tbody>
</table>

Example of simultaneous offer batches
Batching scenarios

Three scenarios of batching offers:

1. **small** batch size:
   2 centers regionally and 5 centers nationally

2. **medium** batch size:
   5 centers regionally and 10 centers nationally

3. **large** batch size:
   10 centers regionally and 20 centers nationally
Kidneys accepted; small versus large batches

• Additional 480 high DRI kidneys (KDRI > 85) placed
  – 1257 (65%) placed with small batches
  – 1737 (89%) accepted with large batches

• Additional 717 other kidneys (KDRI < 85) placed
  – 10,085 (92%) accepted with small batches
  – 10,802 (98%) accepted with large batches
Estimated placement time and discard of organs with KDPI <= 85%

Acceptance rate

<table>
<thead>
<tr>
<th>batch size</th>
<th>discard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>92%</td>
</tr>
<tr>
<td>Mid</td>
<td>97%</td>
</tr>
<tr>
<td>Large</td>
<td>98%</td>
</tr>
</tbody>
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Placement time (first 10h)

<table>
<thead>
<tr>
<th>batch size</th>
<th>within 10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>89%</td>
</tr>
<tr>
<td>Medium</td>
<td>93%</td>
</tr>
<tr>
<td>Large</td>
<td>98%</td>
</tr>
</tbody>
</table>
Estimated placement time and discard of organs with KDPI > 85%

### Placement batch (hour); KDPI > 85%

<table>
<thead>
<tr>
<th>Batch Size</th>
<th>Accepted Organs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>58%</td>
</tr>
<tr>
<td>Medium</td>
<td>73%</td>
</tr>
<tr>
<td>Large</td>
<td>89%</td>
</tr>
</tbody>
</table>

### Acceptance rate

<table>
<thead>
<tr>
<th>Batch Size</th>
<th>Discard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>65%</td>
</tr>
<tr>
<td>Mid</td>
<td>85%</td>
</tr>
<tr>
<td>Large</td>
<td>89%</td>
</tr>
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### Placement time (first 10h)

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<td>73%</td>
</tr>
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<td>Large</td>
<td>89%</td>
</tr>
</tbody>
</table>
Surgeon’s workload: counting offers

- Making simultaneous offers to more centers per batch would increase surgeons’ workload
- Early DonorNet was criticized for “waking people up in the middle of the night six times a night for an [organ] that was never going to come to them”
- We quantify the average weekly number of non-local offers per center in our simulation
## Offers per week

<table>
<thead>
<tr>
<th></th>
<th>All kidneys</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regional</td>
<td>National</td>
<td>Total</td>
</tr>
<tr>
<td>Small batch</td>
<td>3.2</td>
<td>6.9</td>
<td>10.1</td>
</tr>
<tr>
<td>Medium-size batch</td>
<td>3.2</td>
<td>10.8</td>
<td>14.1</td>
</tr>
<tr>
<td>Large batch</td>
<td>3.3</td>
<td>13.5</td>
<td>16.8</td>
</tr>
</tbody>
</table>
Centers that opt out

• The only way for centers to opt out of simultaneous offering is to decline all non-local offers

• Our results show that both high- and low- DRI kidneys should be offered in simultaneous batches
Simultaneous offers

- Simultaneously expiring offers rescued 1197 kidneys from discard
- Simultaneously expiring offers decreased cold ischemia time; about 10% more low-DRI and 50% more high-DRI kidneys were placed in fewer than 10 hours
- Rescuing these kidneys means OPOs will make more offers and centers will screen more offers; about 60% increase in number of national offers screened
Skip non-aggressive centers

• Skipping: kidneys identified as non-ideal or at risk of discard or delay would be offered only to “aggressive” centers that have demonstrated willingness to accept such kidneys, which means skipping all candidates at non-aggressive centers

• Adjustment mechanism: what if a center wishes to change its aggressiveness?
Open offers

• Open offers: a kidney is offered to a center for any candidate on their waitlist, which means skipping every candidate listed at any other center
Novel approaches: utilization and allocation

- Center aggressiveness report cards
- Benefit calculators
- Save it from the trash: get it for free
- Reduce geographic disparity
- Simultaneously expiring offers
- Skip non-aggressive centers
- Open offers
## Core Faculty

- Andrew Cameron, MD PhD
  - Professor of Surgery
- Nadia Chu, MPH PhD
  - Instructor of Surgery
- Christine Durand, MD
  - Associate Professor of Medicine
- Jacqueline Garonzik-Wang, MD PhD
  - Director of Training and Education
  - Assistant Professor of Surgery
- Sommer Gentry, PhD
  - Professor of Mathematics (USNA)
- Macey Henderson, JD PhD
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  - Assistant Professor of Surgery & Nursing
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  - Assistant Professor of Surgery and Epidemiology
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  - Assistant Professor of Pediatrics
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- Tanveen Ishaque
- Jennifer Motter
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- Sile Yu

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- Arthur Love
- Amrita Saha
- Madeleine Waldram

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- Sneha Kunwar
- Eileen Rosello
- Estefania Velez

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- Courtenay Holscher, MD
- Kyle Jackson, MD
- Amber Kernodle, MD
- Martin Kosztowski, MD
- Francisco Rivera, MD
- Jessica Ruck, MD
- Sharon Weeks, MD
- Heather Wasik, MD

## Med/Grad Students

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- Jane Long
- Hasina Maredia
- Nicholas Siegel
- Esha Hase
- Leyla Herbst
- Kathryn Marks
- Taylor Martin

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- Jason Wheatley, LCSW-C
  - Transplant Social Work
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- Jayme Locke, MD MPH
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Non-ideal kidneys (with higher KDPI) still give survival benefit
Infectious-Risk Donors

• US Opioid epidemic: almost 30% of donors are IRD
• Discard rates 2x higher for IRDs than non-IRD counterparts
• Seems wasteful to discard these: there should be someone on the list who would benefit
Turn down for what? Patient outcomes associated with declining increased infectious risk kidneys

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2Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD, USA
3Department of Mathematics, United States Naval Academy, Annapolis, MD, USA
4Scientific Registry of Transplant Recipients, Minneapolis, MN, USA

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Funding information
National Institute of Diabetes and Digestive and Kidney Diseases, Grant/Award Number: K24DK101828, F30DK095545, K01DK101677 and F32DK109662; American
Infectious risk donors are higher-quality

Median (IQR): 52 (30-72)

Med (IQR): 21 (10-38)
Patients accepting infectious risk donors were less likely to die in 5 years.
Identifying Appropriate Recipients for CDC Infectious Risk Donor Kidneys

E. K. H. Chow¹, A. B. Massie¹, A. D. Muzalee¹, A. L. Singer¹, L. M. Kucirka¹, R. A. Montgomery¹, H. P. Lehmann³ and D. L. Segev¹,²,*

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²Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD
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*Corresponding author: Dorry Segev, dorry@jhmi.edu
¹Both authors contributed equally.

donors; NAT, nucleic acid testing; OPTN, Organ PROCUREMENT and transplantation Network; PHS, Public Health Service; PRA, panel reactive antibody; SRTR, Scientific Registry of Program Recipients; T2D, time to death after transplantation with a non-IRD kidney; W2D, time to death from the waitlist; W2T, time to transplant from the waitlist

Received 19 September 2012, revised 23 October 2012 and accepted 19 November 2012

Background
Should candidate accept an IRD kidney? Markov Decision Process Model

Chi
Tx in HAV+HCV

Hi
Tx in HAV

Hc
Tx in HCV

Hic
Tx in HAV+HCV

Wic
HAV+HCV

Tic
Tx after HAV+HCV

H
Transplant

Hi
Tx in HAV

W
hospital

Death
T2W

T2D

T12D

Tc2D

Tc
Tx after HCV

W2D

Wc2D

Wc
HAV

W
hospital

T
Transplant

Chow/Segev AJT 2013
Johns Hopkins IRD Kidney Transplant Calculator

Recipient Characteristics:

- **Age:** (20-75) 50
- **Gender:** female
- **ABO:** Type A
- **Ethnicity:** White
- **BMI:** (19-39) 23
- **PRA:** (0-100) 0
- **Renal failure diagnosis:** diabetes mellitus
- **Previous transplant:** no
- **Years on waitlist:** 0
- **Estimated time remaining until non-IRD transplant:** 48 months

* This is time in addition to the time the patient may have already waited. eg: if a patient has spent 1 year on the waitlist, and the estimated time remaining until a non-IRD transplant is 18 months, the patient is expected to have waited 30 months since listing, before a non-IRD transplant.

Donor Characteristics:

- **Infectious Risk Behavior:** Intravenous drug users
- **Serology Testing Used:** ELISA

base-case estimate: mortality risk (if seroconverted) increased by 4.12% HIV, 3.42% HCV per year

worst-case estimate: mortality risk (if seroconverted) equivalent to immediate (100% chance) death

www.TransplantModels.com/IRD
Johns Hopkins IRD Kidney Transplant Calculator

Patient Survival

Recipient Characteristics:
- Age: 50
- Gender: female
- ABO: Type A
- Ethnicity: White
- BMI: (19-39)
- PRA: (0-100)
- Renal failure diagnosis: diabetes mellitus
- Previous transplant: no
- Years on waitlist: 0
- Estimated time remaining until non-IRD transplant*: 3 months

* This is time in addition to the time the patient may have already waited, e.g., if a patient has spent 1 year on the waitlist and the estimated time remaining until a non-IRD transplant is 18 months, the patient is expected to have waited 30 months since listing, before a non-IRD transplant.

Donor Characteristics:
- Infectious Risk Behavior: Intravenous drug users
- Serology Testing Used: ELISA

Selected Patient Characteristics:
- SDF white, abo: A
- BMI: 23, PRA: 0, dx: DM
- prev transplant: no, yrs on dialysis: 3 months
- infectious risk: IDU/ELISA

Base-case estimate: mortality risk (if seroconverted) increased by 4.12% HIV, 3.42% HCV per year
Worst-case estimate: mortality risk (if seroconverted) equivalent to immediate (100% chance) death

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