Kidney Exchange in Scandinavia

Prof. Tommy Andersson
Lund University
Outline of the talk

- Kidney Exchange:
  - Europe
  - Ideas
  - Sweden
- Matching techniques and software
- STEP
  - Sweden
  - Scandinavia
- European Network for Collaboration on Kidney Exchange Programmes (ENCKEP)
- Conclusions
Kidney Exchange in Europe

Figure 3: Development of KEPs by country (based on our questionnaire)
## Kidney Exchange in Europe

**Table 1: Summary table on system and society. The ten countries with operating KEPs at the time of writing are coloured with blue in the table.**

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Kidney Exchange in Europe

Figure 5: KEP activity for all years until end of the most recent year for 10 countries

![Bar chart showing number of recipients transplanted (blue) and registered (red) in KEP in total until the end of 2016 for various countries including Austria, Belgium, Czech Republic, France, Italy, Netherlands, Poland, Portugal, Spain, and UK.](image-url)
Pairwise Exchanges

Donor A

Patient A

Donor B

Patient B
Pairwise Exchanges

- Donor A
- Patient B
- Donor B
- Patient A
More advanced exchanges

• A Kidney Exchange Program (KEP) may also include:
  – Larger cyclical trades (3-way and 4-way)
  – List exchanges with altruistic donors
  – Etc.

• Sweden: initially only pairwise exchanges (2-way)
Kidney Exchange in Sweden

• The first step towards a KEP was taken in late 2013 (informal conversations)
• A group containing transplant doctors, immunologists and a matching theorist was formed in 2014
• Immunological protocols, general rules and software was developed during 2015 and 2016
• STEP Sweden was launched in late 2016
Practical procedure

- Data for each patient-donor pair is reported to iSMART (PRA, HLA, DSA, blood group, etc.)
- A compatibility matrix and a vector of matching probabilities are generated and exported to STEPone
- STEPone contains the matching algorithm
Compatibility matrix

- Compatibility matrix \((K)\) where patients are stated in the rows and donors in the columns

\[
K = \begin{bmatrix}
0 & 1 & \cdots & 1 & 0 \\
0 & 0 & \cdots & 0 & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
1 & 0 & \cdots & 0 & 1 \\
0 & 1 & \cdots & 1 & 0 \\
\end{bmatrix}
\]
Compatibility matrix (September 18)

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Associated graph
Goals of the matching algorithm

• The goals of STEP are (STEP programme 1.7):
  – The maximal number of transplanted patients
  – Low match probability
  – Compatible blood groups
Associated graph
Maximal cardinality
Matchning probabilities

• Calculation of MP (Keizer et al., Transplantation Proceedings, 2005)

  – A donor pool consists of 25 donors, of which 13 donors have ABO blood group O. In this example the MP for 2 of 25 recipients are calculated.

  **EXAMPLE Recipient 1:** ABO blood group O, HLA unacceptables: A1, DR1, and a %PRA of 57. Seven donors have either A1, DR1 or both; in theory this recipient can be matched to 6 of 13 donors.

  \[
  \text{MP recipient 1} = (1 - \%PRA) \times \left(\frac{6}{13}\right) \\
  = (1 - 0.57) \times 0.46 \\
  = 0.2
  \]

  **EXAMPLE Recipient 2:** ABO blood group O, no HLA unacceptables, and a %PRA of 0.

  \[
  \text{MP recipient 2} = (1 - 0) \times \left(\frac{13}{13}\right) \\
  = 1.0
  \]

• Additional “small” modification of matching probabilities are necessary to guarantee maximality of compatible blood groups
MP och priority

MP(1)+MP(2)

1

2

3

4

MP(1)+MP(4)

MP(1)+MP(3)
iSMART

- iSMART: national software for registering pairs (medical data, medical history, etc.)
- Web interface, secure servers, etc.
- Developed by Ragnar Källen (Skånes universitetssjukhus)
- NOTE: Scandiatransplnat is currently developing their own corresponding software
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STEPone

• Matching algorithm
• In-house implementation in MatLab by Tommy Andersson
• Scandiatransplant has received all code and documentation (February 2017)
• Scandiatransplant will migrate the code to JAVA
• The mathematics behind the algorithm can be found at: https://ideas.repec.org/p/hhs/lunewp/2016_011.html
STEP – in Sweden

• STEP launched in late 2016 ➔ no transplants yet
• Currently 7 pairs enrolled in the KEP (8 donors)
• Problems:
  – Public awareness
  – Highly sensitised patients (85% with PRA>85%)
  – Competition from ABOi transplants (outside of KEP)
  – Backlog in registering in iSMART?
  – Small country
STEP – in Scandinavia

• NKG meeting in October 2016
• Norway and Denmark will join STEP
• February 2017: Andersson to Scandiatransplant HQ
• April 2017: STEP meeting in Copenhagen
• Scandiatransplant is currently working on the IT structure (in collaboration with Tommy Andersson)
• Hopefully: Sweden-Norway-Denmark in 2017/2018
  – A larger pool cannot hurt the KEP
ENCKEP

- European Network for Collaboration on Kidney Exchange Programmes
- Launched in late 2016
- All European KEPs are represented (mathematicians, transplant doctors, immunologists, coordinators, etc.)

- Idea: to exchange ideas, practices, experiences, software, mathematical techniques, etc.
- http://www.cost.eu/COST_Actions/ca/CA15210
Lessons from ENCKEP

• Increase public awareness
• Do not only include highly sensitised patients
• Before transplanting across the blood group barrier outside of the KEP, include the pair in the KEP to identify a pairwise exchange (this can mean two transplants instead of one!)
• Ask existing ”problematic” pairs to be part of the KEP (this can mean two transplants instead of one)
• Include altruistic donors
• Better self confidence – believe in the KEP!
• Expand the KEP to Denmark and Norway (remember Netherlands)
Lessons from ENCKEP
Lessons from ENCKEKP

- Increase public awareness
- Do not only include highly sensitised patients
- Before transplanting across the blood group barrier outside of the KEP, include the pair in the KEP to identify a pairwise exchange (this can mean two transplants instead of one!)
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- Include altruistic donors
- Expand the KEP to Denmark and Norway (remember Netherlands)
Conclusions

• Software as well as medical practices exist today
• Progress in Sweden slow (but still optimistic)
• Scandinavian KEP in 2017/2018
• Problems:
  – Public awareness
  – Include only high PRA
  – Competition from ABOi transplants (outside of KEP)
  – Slow registration
  – Small country
THANKS!

Website: https://sites.google.com/site/tommyanderssonlunduniversity/home