Modern Kidney Exchanges

Algorithms, Market Design and Opportunities

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Abstract

In the case of kidney transplantation, there is always a serious imbalance between the number of kidneys donated for transplantation and the number of persons wishing to receive a transplant. This not only affects the quality of life of those unable to obtain a transplant, but it also has important consequences on the treatment of End Stage Renal Disease (ESRD) by transplantation. Most transplanted kidneys are from cadavers, but there are also many transplants from live donors. Recently, there have started to be kidney exchanges involving two donor-patient pairs such that each donor cannot give a kidney to the intended recipient because of immunological incompatibility, but each patient can receive a kidney from the other donor. Exchanges are also made in which a donor-patient pair makes a donation to someone waiting for a cadaver kidney, in return for the patient in the pair receiving high priority for a compatible cadaver kidney when one becomes available. There are strict legal constraints on how exchanges can be conducted. This project will explore how larger scale exchanges of these kinds can be arranged efficiently and incentive compatibly, within existing constraints that would result in the substantial welfare gains from larger scale exchange, both in increased number of feasible live donation transplants, and in improved match quality of transplanted kidneys.

Introduction

The role of kidneys is to filter waste from blood. Kidney failure results in accumulation of this waste, which leads to death in months. One treatment option is dialysis, in which the patient goes to a hospital to have his/her blood filtered by an external machine. Several visits are required per week, and each takes several hours. The quality of life on dialysis can be extremely low, and in fact many patients opt to withdraw from dialysis, leading to a natural death. Only 12% of dialysis patients survive 10 years.

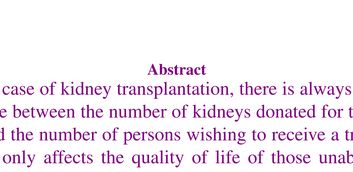

Figure 1: Painful Kidney Dialysis

Instead, transplantation is the preferred treatment for the most serious forms of kidney disease. Many kidney-disease patients, the best option is to find a living donor, a healthy person from family willing to donate one of his/her two kidneys. But If there is blood-type incompatibility between donor and patient, then patient fails to get kidney and he has to wait.

There is thus a considerable shortage of kidneys, compared with the demand. Although there are marketplaces for buying and selling living-donor kidneys, the commercialization of human organs is almost universally regarded as unethical, and the practice is often explicitly illegal, according to Transplantation of Human Organs Act, 1994. However, live donation is legal, provided it occurs as a gift with no financial compensation.

Transplants form live donors generally have a higher chance of success than those from cadavers. The number of live donations would have been much higher if it were not for the fact that, frequently, a potential donor and his intended recipient are blood-type or tissue-type incompatible. In the past, the incompatible donor was sent home, leaving the patient to wait for a deceased-donor kidney.

Recently in a small number of cases, additional possibilities have been utilized when a transplant from a live donor and the intended recipient is infeasible. One of these, called a two paired kidney exchange, involves two patient-donor couples, for each of whom a transplant from donor to intended recipient is infeasible, but such that the patient in each couple could feasibly receive a transplant from the donor in the other couple. This pair of couples can then exchange donated kidneys. Compared with receiving cadaver kidneys at an unknown future time, this improves the welfare of the patients. In addition, it relieves the demand on the supply of cadaver kidneys, and thus potentially improves the welfare of those patients on the cadaver queue.

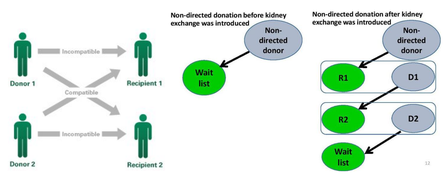

Figure 2: Two pair Kidney Exchange(left) & Chains with Deceased Donor(right).

Discussion

This project reports recent changes in kidney exchange design. (For some other work around the world see http://marketdesigner.blogspot.com/) In particular, kidney exchange protocols operate in medical environments in which patients, surgeons and transplant centers have very large strategy spaces. In developed countries kidney exchange has become a standard mode of transplantation, the major players have adapted to it, in ways that in turn require changes in kidney exchange.

Current Scenario

The global prevalence of Chronic kidney disease (CKD) is estimated to be 8-16%,and the disease burden is expected to grow. In India, recent studies have shown a variable prevalence ranging from 4% to 17.2% with wide regional differences.Globally, CKD is associated with high morbidity and mortality with approximately 735,000 deaths annually. Thus, CKD is the 12th most common cause of death and the 17th most common cause of disability. According to National Organ & Tissue Transplant Organisation(NOTTO) there were only 1,917 kidney transplants while the requirement was for over 200,000 kidneys. If we use optimal allocation and exchange algorithms for cadaveric and live donations, it can bridge gap to some extent and reduce wait time for kidney transplantation. Prof. Alvin E. Roth and Prof. Tuomas Sandholm both working in field of kidney exchange and market design for more than 25 years in United States. In USA 17,105 kidney transplants took place in 2014, of these 11,570 were form deceased donors and 5535 form living donors and this is growing every year. This motivates to work on kidney allocation and exchange algorithms in India also. In India, deceased organ donation program is still in its infancy, largely restricted to big institutions and hampered by the lack of a national policy for organ recovery or allocation, this should be improved and better utilization of donated organs should be done.

Proposed Work

Currently in these kidney exchange, patients with terminal kidney disease try to swap their incompatible donors with each other in order to get a compatible donor.In the initial run, My main idea in this area is an algorithm for finding the best set of swaps. These type of algorithm are used by the United Network for Organ Sharing(UNOS) for use in their upcoming nationwide kidney exchange, where it is expected to save thousands of lives and hundreds of millions of dollars a year in health care costs. Each pair includes a potential donor who is not medically compatible with his or her original intended recipient, or is less than an optimal match. In the matching process, the computer looks for new combinations between the pairs based on compatible blood and tissue types. For example, in a two-way exchange, the donor from one pair is matched with a compatible recipient from a second pair, while the donor from the second pair is matched with the recipient from the first pair. We would consider the scenario that it can sometimes be best to wait on some of the transplants so that more or better transplants can be found as new pairs enter the system.

In India there are smaller, existing kidney exchanges, which take these incompatible donor-recipient pairs and match them with other donor-recipient pairs, already have boosted the number of KPD transplants. We would consider nationwide organ sharing network or national pool in India because establishing a national pool could boost kidney transplants because the chances of finding compatible matches increase as the size of the exchange pool grows.

After this I will focus on strategies that will include regional, national, international exchanges, list exchange, three-way, domino chain, and non-simultaneous Kidney Transplants.

Expected Results

I expect this will result in efficient utilization of cadaver and live kidney donations so that lesser number of people are on kidney waiting list, and improved match quality of transplanted kidneys. This will encourage people to donate organs and save other people's lives.

Support

This project would require collaboration of people from all related areas, support from hospitals and Nephrologists for successful practical implementation are must for this to work.

References

[1] Tayfun Snmez Roth, Alvin E. and M. Utku nver. "kidney exchange,". *Quarterly Journal of Economics*, 2(119):457–488, May 2004.