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Research News

Kidney Exchange: A Life-Saving Application of Matching Theory

Economists help build a kidney exchange system that saves lives.

October 5, 2005

Editor's note: On March 28, 2007, the Justice Department issued a legal memo stating that paired kidney donations do not violate a provision of the National Organ Transplant Act that makes it illegal to acquire an organ for transplant in exchange for "valuable consideration." The Justice opinion, issued in response to a question from the Department of Health and Human Services, is expected to increase the number transplants resulting from paired donations.

This year, more than 60,000 people in the United States will need a kidney transplant. Of that number, roughly 15,000 will receive transplants from either cadavers or living donors. But for those who aren't so lucky, the prospects have gotten better thanks to a kidney exchange system developed by Harvard economist Alvin Roth, Tayfun Sonmez of Boston College and Utku Unver of University of Pittsburgh.

Roth and his colleagues' NSF-supported research employs economic matching theory in developing a system for optimizing the search for live kidney-donor transfers. (Live donation is an option for kidneys, since most people have two kidneys and can remain healthy with one.) The system matches incompatible donor-patient pairs—in which each donor is unable to give a kidney to the intended recipient because of immunological unsuitability—with similarly incompatible pairs so that each patient can receive a kidney from a compatible donor. The system, which was based on an idea for dormitory housing allocations, has led to the establishment of a kidney exchange clearinghouse for patients needing transplants in the New England area. Applied nationally, the system could shorten the wait time for kidney transplant patients and potentially save thousands of lives.

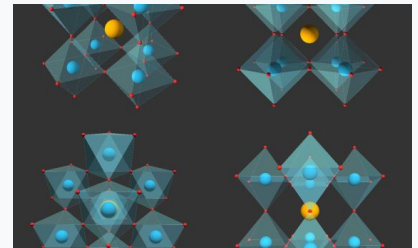
Allocating Dorm Rooms and Kidneys

According to Roth, the application of the dorm-room model to a kidney exchange network was quite natural. "In the 1970s the metaphor was everyone had a house and you might want to swap houses. There were a series of papers from the 1970s," he explains, "that explore—in highly abstract terms, with no practical applications—the exchange of goods with no money entering into the bargain. This is particularly important because of the National Organ Transplant Act that makes it a felony to exchange body parts for money," adds Roth.

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"In the '90s, economists looked at the problem of assigning dormitory rooms. Dormitory rooms have the property that some dormitory rooms are empty; some people on the market don't have any rooms; and some people on the market have rooms, but might want better rooms," explains Roth. "This is similar to the kidney picture in that there are deceased donors, so there are kidneys with no people. There are people with no kidneys. And there are people with kidneys. That's the basis of the exchange—the incompatible patient donor pairs. So there is a natural parallel between the dormitory room problem and the kidney problem."

In September 2004, the Renal Transplant Oversight Committee of New England approved the establishment of a new computerized donor tracking system for kidney exchange developed by Roth, Sonmez and Univer, with Francis Delmonico and Susan Saidman. Delmonico is a professor of surgery at Harvard Medical School and president of the Organ Procurement and Transplant Network (OPTN) and Saidman is a tissue-typing surgical specialist at Harvard. The system would allow doctors in New England hospitals to arrange kidney exchanges.

For transplant surgeons like Delmonico, who are involved in the practical application of this model, its potential is significant. "Kidney exchange enables transplantation where it otherwise could not be accomplished," says Delmonico. "It overcomes the frustration of a biological obstacle to transplantation. For instance, a wife may need a kidney and her husband may want to donate, but they have a blood type incompatibility that makes donation impossible. Now they can do an exchange. And we've done them. Now we are working on a three-way exchange."

Economic Theory with Medical Applications

Matching theory enables the investigators to design a system that solves important incentive issues. Patients and surgeons have an incentive to bring forward all available incompatible donors—even though only one will donate—and provide as much medical data as possible. The clearinghouse gives surgeons and transplant centers an incentive to enroll their incompatible donor pairs so that the best possible match may be found.

The system requires simultaneous transplants, otherwise incentives can be affected. For example, a donor might decide not to go through with donating his or her kidney after the patient of that pair has received a transplant, leaving the other pair donating the kidney at a loss. The principal investigators present simulation results suggesting that the welfare gains from large-scale exchange would be substantial—both in increased numbers of feasible live donation transplants, and in the improved match quality of transplanted kidneys.

Creating a Large Kidney Exchange Database

One of the problems, observes Roth, is creating kidney exchange databases with enough donor information. Roth estimates that up to as many as half of the willing donors who prove to be incompatible—their blood types don't match the patients' or the patients' immune systems would attack the donated organs—cannot donate because there is no system for keeping track of rejected donors.

"The customary medical practice has been that if I wanted to give you a kidney, I would go with you to visit your nephrologist (kidney doctor) and they would take a blood test," says Roth. "It might be that you and I are blood type incompatible. And at that point, I would go home. I wouldn't be in your medical records," he explains. "So the first thing you have to do to get kidney exchanges is not send the incompatible donors home. You say, 'Why don't you sign this consent form and give us another blood sample and we'll see if we can do an exchange.' We are still working on that."

As of last December, only five exchanges had been performed in the 14 transplant centers in New England. In an effort to increase those numbers, this year the Kidney Exchange Consensus Conference—a meeting of all the principle transplant centers—decided to adopt a national kidney exchange, which should go a long way toward developing more extensive databases.

"Right now we're not helping many patients because we are just getting started," says Roth. "Last year there were about 8,000 deceased donor transplants in the United States. There were about 6,000 live donor transplants and hardly any exchange transplants. But given the number of live donor transplants," he adds, "one supposes that for every live donor transplant there might be some incompatible donors out there. So we are guessing that at the moment, nationally, there would be 2,000 to 3,000 that you might be able to do on an annual basis," he says. "We are far from that now."

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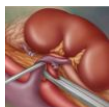
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A depiction of the kidney as seen in a live donor transplant.

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