

PODCAST for INFORMS

(Moderated by Barry List)

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With 80,000 Americans awaiting kidney transplants on any given day, the sad fact is that many people with renal disease will wait years and some will die before a suitable kidney becomes available. A new system for scheduling a fleet of airplanes to fly recipients to cities with available organs may substantially reduce that waiting time. Hear Sridhar Tayur of Carnegie Mellon University and physician Anton Skaro of Northwestern University preview the paper that co-author Baris Ata will present at INFORMS Healthcare 2011, which takes places in Montreal from June 20-22.

What is the motivation for OrganJet?

(Sridhar Tayur)

It was somewhat fortuitous that I had dinner with Baris Ata, who could not be on the call today. He gave me a quick summary of the research he was doing, and as part of that discussion, I understood that there were three main aspects of the issues in the organ transplant market in the US. First, there is a shortage of supply. Second, there are regional differences with regard to this shortage. Third, there is a local control on these organs that when harvested in region, they tend to stay in the region.

What occurred to me is that perhaps my previous experience with fractional jet scheduling that companies like NetJets use now

could be brought to bear to see if we can very simply democratize Steve Jobs.

Can we have planes ready close to the patients at the time needed to take them to place that transplant can occur thereby helping more people who currently may be waiting too long and unfortunately may not get the organ in time? And that really is how OrganJet got created.

What is UNOS and how does it operate?

(Anton Skaro)

United Network for Organ Sharing (UNOS) is a nonprofit organization with scientific and educational parameters. It was first created when the national organ transplant act came into effect in 1984. In a broad sense, their responsibility is with the regulation and oversight of organ transplantation in the US, and most applicable to the topic of hand, is their job related to allocation of organs once these organs become available. They decide who gets the organ.

What is the service that OrganJet provides and what is the need that it fulfills?

(Sridhar Tayur)

OrganJet is complementary to the work being done in the allocation of organs.

We do not affect the rules of the allocation. Whatever be the allocation rules that UNOS has agreed to execute, we want to make

sure that patients who live far away from where the organs are available have access to it. We try to bring the service that very rich people like Steve Jobs have to more normal people by making it very affordable to have a private jet in a timely manner to take them from home location to transplant location. It is that simple actually.

Why do you recommend bringing the patient to the harvested organs rather than transplanting a donated kidney to the patient?

(Anton Skaro)

These organs are a rare and precious resource. At this point, they are felt to be a resource of the particular local in which they are derived from. Although UNOS is governing body at the national policy, the organ allocation policies are actually enforced at a more local regional level. There are distinct rules, or variances, that predilect these organs to stay within those locales. From a logistical standpoint, it becomes almost impossible to modify and reform organ allocation policy so that these organs can be sent to where patients are, where the need is. There are tremendous imbalances and variation across the country in terms of organ availability, and hence waiting times for these organs, and it became far more sensical to bring the patients to the organs given the tremendous obstacles in front of us, and the willingness or rather the reluctance for these areas to give up these rare and precious resources. So if we cannot bring the

organs to the patients, the next most logical thing, the next most simplest thing, was to identify a way in which to bring the patients to the organs, and that's how OrganJet was created.

So far have the local governing groups found that this meets their guidelines?

(Anton Skaro)

Absolutely. There are no laws or policies in place that would obviate the ability of patients that have the means to list at multiple centers in multiple regions and donor service centers in order to gain access to these organs for transplantation.

The perfect example would be the issue of Steve Jobs who chose to have his transplant performed in Tennessee.

Who owns the fleet of planes?

(Sridhar Tayur)

We will not own the planes. We will have timely access to them. Right now, we are working with private individuals who have business jets as well as small providers of charter jets to make sure we have adequate number of them at the right locations.

How have you used your training in math modeling to deal with the problems of organ donation, or more specifically in this first stage, kidney donation?

(Sridhar Tayur)

There are three areas of operations research that are being used for OrganJet.

First, queuing networks is a well-known area of operations research, and considering the patients and organs at various centers in the US that can be linked can be modeled as a queuing network.

Second, we use equilibrium analysis using game theory. Game theory from economics has gone beyond economics. We are also trying to understand within OrganJet since everyone is trying to maximize their own chance of getting a kidney as fast as possible, what is the equilibrium when people do what is called selfish routing. The second area of operations research / economics is game theory.

Both of these are at the conceptual level.

From the operational level, where the rubber actually meets the road, it goes back to scheduling. How do you actually schedule the planes to take someone from place A to place B in a timely and efficient manner? This area of operations research has a long heritage.

OrganJet was interesting not only for what it was trying to do for society, but also the fact that it brought together these three areas of operations research in terms of analysis and execution.

How does multiple listing work?

(Anton Skaro)

Multiple listing is a phenomenon that already exists. But the scale at which it currently exists is very minute. Currently 1% or less of patients in the US are multiple listed. That is they are listed for transplant at multiple centers usually within distinct donor service areas or regions.

So if an organ becomes available in one of those regions, they can be called up and brought in and receive a transplant. Currently these are usually regions that are above one another. Transplantation is usually land-based and at that point, patients can have access to this multiple listing phenomenon. Our vision of this system is to expand the geographic scope of the multiple listing. This is facilitated by the OrganJet concept where patients can multiply list at other regions or donor service centers that are distant for land travel but very reasonable for air travel.

One of the constraints that we are faced with is maintaining the amount of time that the organ is without its blood supply, called cold ischemia time. In general for kidney transplants, we like to get these transplants reperfused within a 24-hour timeframe, and occasionally longer. This cold ischemia time can be lengthened by attaching the kidneys to mechanical pumping mechanism that perfuses the kidneys with a cold solution that extends their viability. The concept of multiple listing would be to increase not only the distance that patients

can multiple list but also expand the number of patients that multiple list from **1% to 20-25%** of patients. This is a large increase but also is quite feasible.

This could have a significant impact on the waiting list in the US.

How distant could a donor service area be and still be a choice for patient?

(Sridhar Tayur)

Business Jets (Hawker 400 or Citation Ultra) can travel 1,000 miles in under 3 hours. If someone is multi-listed so they can drive in 3 hours, imagine how much they can multi-list if they can fly somewhere in 3 hours.

Someone in Boston could multi-list in Tampa in OrganJet. Without Organ Jet and if they were not particularly wealthy, they would not even think about it.

This brings up two issues. One, by making the possibility of multiple listing affordable but also creating the distance of which people can multi-list, should increase the number of people who would choose to multi-list. Two, by multi-listing, they will take demand away from Boston, and put more in Tampa, and therefore equalize the traffic in these regions, and in the limit, these waiting times across regions that can be connected by OrganJet will be nearly equal. Again, in a perfect mathematical world, I am sure we can equalize the waiting times. But if we can reduce the gap. In Boston, if the waiting time is 3 years, and in

Nashville, its 7 months. That's a large variability, Maybe they both equalize to 9.5 months.

(Anton Skaro)

In Chicago region, some of the waiting times are 7 years. If we can get that down to 1 year, and some of the simulation work that has been done has shown that that is a possibility.

How would the supply increase in this system? Why does your system allow for the acceptance of organs that don't currently qualify to be transplanted?

(Anton Skaro)

In areas, where the supply demand algorithm is in a better light, that is where we have a plentiful supply of organs and a relatively smaller list, patients are able to wait around to pick and choose organs that are potentially of the best quality. Some of the organs that might go unused would certainly be used in a very competitive kidney market. This is something that could throw the balance in favor of a better matching of donors and recipients.

In areas with larger lists and longer waiting times, generally these patients accrue co- morbid illnesses that make their condition far worse. Their level of aversion to a particular quality of graft will be quite different than a patient that is waiting a short period of time.

It sounds like it improves the system at both ends. It extends the period of time (speeds the time)

that the organ is brought to the recipient, but also it catches the ill person at earlier stage in illness, and better able to deal with transplantation process.

(Anton Skaro)

We would be transplanting patients at far earlier in their disease course and so they are more likely to enjoy a better outcome from the transplant in general.

How many patients can be saved with OrganJet?

(Sridhar Tayur)

We are still running simulations so I can give you a range of anywhere from 2-5 people/day, so 750-1,500 people a year.

(Anton Skaro)

Mortality on the waiting list in the kidney transplant world is difficult to get your arms around because not everyone will be a candidate for transplantation. Perhaps if transplantation is something that we can intervene on earlier on, you may see some expansion in appropriate candidates, but those estimates are likely very accurate.

How much can waiting time be reduced under the system and how can the time that a kidney remains viable be increased?

(Anton Skaro)

In general, the suitable cold ischemia time for a kidney is in realm of 24-36 hours. This period of time in which the viability could be preserved can be lengthened by some of these

mechanical pumping or perfusion systems.

The thought is if we bring the patients to the kidneys that more transplants would be occurring on a local level. We do have some heads up as to when an organ is likely to be allocated. Certainly some patients may travel unnecessarily, but we feel the benefits of reducing cold ischemia and gaining access to kidneys for patients, and mitigating the variability and long waiting times. I can't say enough how important the cold ischemia time is in terms of the eventual outcome, and so any steps we can take to mitigate these logistical issues is a tremendous leap forward.

What are the next steps in the development of OrganJet?

(Sridhar Tayur)

There are few things that are in parallel.

One stream is looking to see who are the first set of patients we should identify who are not multi-listed who should be multi-listed.

We are looking to get feedback from surgeons and also from other parts of medical community. Anton will be working directly with UNOS to get their feedback, and ideally their endorsement for OrganJet.

We are identifying any natural complementary partners for an end-to-end service offering. This is a tough time for the patient. We want to take a patient perspective. Clearly, nobody would like to be on a

transplant list if they can help it. Now that they are on a transplant list, we want to make sure they feel secure and comfortable. To the extent we can help them during their transplantation process and the transplant itself, we want to be able to give them a service that we would expect would be available to our own families. We are trying to see what the natural complementary partners are so that the end-to-end offering of OrganJet can be a civilized offering for our society.

Would this work for livers and other organs?

(Anton Skaro)

Liver has shorter time frame than kidney but enough for OrganJet to be useful.

The appropriate cold ischemia for liver is shorter, and we do like to get these organs in under 10-12 hours. But again, proof is already in the pudding, there has been obviously the Steve Jobs case with the liver, which is absolutely proof of concept.

The other thing that is very important to mention is that a liver is a life saving organ. In the US, approximately 2,000 patients die annually awaiting a liver. The OrganJet solution is likely to have the greatest impact on liver mortality. From a logistical standpoint, the shorter cold ischemia time is going to pose a challenge, but I think it is something that is certainly viable.