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Morbidity and Mortality After Living Kidney Donation, 1999–2001: Survey of United States Transplant Centers

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There have been two recent trends in living kidney donation: increased acceptance of living donors and increased acceptance of laparoscopic nephrectomy (LN).
We surveyed 234 UNOS-listed kidney transplant programs to determine current living donor morbidity and mortality for open nephrectomy, hand-assisted LN, and non-hand-assisted LN.
Of the 234 centers, 171 (73%) responded. Between 1/1/1999 and 7/1/2001, these centers carried out 10 828 living donor nephrectomies: 52.3% open, 20.7% hand-assisted LN, and 27% non-hand-assisted LN. Two donors (0.02%) died from surgical complications and one is in a persistent vegetative state (all after LN). Reoperation was necessary in 22 (0.4%) open, 23 (1.0%) hand-assisted LN, and 21 (0.9%) non-hand-assisted LN cases ($p = 0.001$). Complications not requiring reoperation were reported for 19 (0.3%) open, 22 (1.0%) hand-assisted LN, and 24 (0.8%) non-hand-assisted LN cases ($p = 0.02$). Readmission rate was higher for LN (1.6%) vs. open (0.6%) donors ($p < 0.001$), almost entirely as a result of an increase in gastrointestinal complications in LN donors.
Morbidity and mortality for living donor nephrectomy at transplant centers in the United States remain low. We provide current data from which comprehensive informed consent can be obtained from donors.

Key words: Kidney donor, morbidity, mortality

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Introduction

Two major recent developments have led to the increased acceptance of living kidney donation. First, kidney transplant results have improved, so more patients with end-stage renal disease (ESRD) have opted for a transplant rather than dialysis. At the same time, the number of cadaver kidneys available has not increased. Thus, the waiting time for a cadaver kidney transplant has progressively increased, and, for the first time, a significant portion of patients on the waiting list are dying before receiving a cadaver kidney (1). In the last few years, as a partial solution to the cadaver kidney shortage, the number of living kidney donors has markedly increased (2).

Second, the introduction of laparoscopic nephrectomy (LN) has been associated with less pain and a quicker recovery time than conventional open nephrectomy (3,4). As a result, more potential living donors may volunteer (5).

The major disadvantage of a living donor transplant is the risk to the donor, including perioperative morbidity and mortality, plus the long-term risk of living with a single kidney. Morbidity and mortality after open nephrectomy were described a decade ago (6,7).

Nonetheless, we were concerned that (a) the pressure to increase acceptance of living donors may have led to relaxation of acceptance criteria and a resultant change in donor outcomes and (b) the morbidity and mortality rates with LN may differ from those of open nephrectomy. Thus, to address current donor morbidity and mortality rates, we conducted a survey of transplant centers in the United States.

Methods

A survey was sent to all transplant centers listed with the United Network for Organ Sharing (UNOS).

The Human Subjects Committee at the University of Minnesota determined that the survey was exempt from review under federal guidelines [45 CFR Part 46–101 (b) Category #4]. The research project was also reviewed by the Investigational Review Board of the University of Maryland School of Medicine, which also found it exempt from formal review (exemption number STB-070201). We asked centers to provide the total number of donors they accepted between January 1, 1999, and July 1, 2001, and then the total number performed using each surgical technique: open nephrectomy, hand-assisted (HA) LN, and non-HA LN. For each of these three techniques, we asked for information on mortality, reoperation, complications, and readmissions. For donors having problems (reoperation, complications, readmissions) after either type of LN, we asked whether the problems occurred early or late in the center's experience (< 25 cases, 25–50 cases, or > 50 cases). Finally, we asked whether centers were aware of donors being denied health insurance or life insurance as a consequence of uninephrectomy.

The incidence of reoperation, complications, and readmissions was compared among the three procedures using chi-square and/or Fisher's exact tests.

Results

Of 234 kidney transplant centers surveyed, 171 (73%) responded. Between January 1, 1999, and July 1, 2001, these centers carried out 10 828 living donor (LD) nephrectomies. This represents 85% of living donor transplants reported to the UNOS in this interval. Of these, 5660 (52.3%) were carried out by open nephrectomy, 2239 (20.7%) by HA LN, and 2929 (27%) by non-HA LN.

Of the 10 828 donors, two (0.02%) died from surgical complications (one from pulmonary embolus on postoperative day 5 after HA LN; one unspecified, also after LN). A third donor is in a persistent vegetative state after an intraoperative bleed and hypotension during non-HA LN (carried out within the first 25 cases of the center's experience). Including all three of these donors, the calculated overall mortality rate has been 0.03%. In addition, two other donors have died from nonoperative causes (one murder and one suicide, each at 6 months after donation).

Reoperation has been performed in 25 (0.4%) open, 23 (1.0%) HA LN, and 21 (0.9%) non-HA LN donors ($p = 0.001$). Reasons for reoperation differed by donation technique (Table 1). Bleeding was a more common reason for reoperation with non-HA LN donors ($p = 0.02$); hernia with HA LN and open donors ($p = 0.001$). For LN donors, the four main reasons for reoperation seemed to have little relation to the center's LN experience, although the numbers in each group are small (Table 2).

Postoperative complications not requiring reoperation were reported for 19 (0.3%) open, 22 (1.0%) HA LN, and 24 (0.8%) non-HA LN donors ($p = 0.02$) (Table 3). These numbers are likely underestimated. For example, some centers may not have reported bleeding requiring transfusions unless reoperation resulted.

One unusual complication (rhabdomyolysis) (n = 6.0.1%) seemed to be related to large donors and a prolonged operative time. The occurrence of bleeding (not requiring reoperation) and of rhabdomyolysis seemed to have no relation to the center's LN experience (Table 4).

Reasons for readmissions are shown, by donation technique, in Table 5. Our survey separated readmissions by open nephrectomy vs. LN, but did not separate HA LN from non-HA LN. The readmission rate was significantly increased for LN donors ($p < 0.001$), almost entirely as a result of gastrointestinal complications (nausea and vomiting, dehydration, ileus, or constipation). It is unclear how much of this increase was the result of the intraperitoneal approach or how much was because of the goal of early hospital discharge after LN. For 45 readmissions after LN, we were able to determine the donation technique: we found no difference in reasons for readmissions for HA LN vs. non-HA LN donors (Table 6).

Finally, five centers reported that one or more donors have had difficulty obtaining health insurance or life insurance. For three of these centers, the issue was quickly resolved after direct communication between the center and the insurance company. One donor who was denied personal insurance was eventually covered by a spouse's policy.

Discussion

The most challenging dilemma in kidney transplantation today is an insufficient number of suitable organs for transplantation and the resultant increased waiting time for prospective cadaver donor recipients. In the last decade, the number of patients on the waiting list for a kidney in the United States has increased from 19 046 to 47 831 (2) and the median time from listing to transplant has increased from 514 to more than 1131 days. One potential solution to this problem is to increase the number of LD transplants. In 2001, the number of LD donors exceeded the number of cadaver donors.

In addition to the longer waiting times for a cadaver kidney, other possible reasons for this recent LD increase include the following: First, patient and graft survival rates after LD transplants are better than after cadaver transplants (8). Outcome after preemptive transplants (which are much more likely with LD) is better than outcome for patients on dialysis pretransplant (9,10). Clearly, from a recipient perspective, an LD transplant is better. Second, numerous studies have shown that outcome after living

Table 1: Reasons for reoperation; by donation technique

	Open (n = 5660)	HA LN (n = 2239)	Non-HA LN (n = 2929)
Bleeding*	9 (0.15%)	4 (0.18%)	13 (0.45%)
Bowel obstruction**	3 (0.05%)	6 (0.27%)	3 (0.1%)
Bowel injury	–	2 (0.1%)	4 (0.14%)
Hernia***	10 (0.18%)	11 (0.5%)	1 (0.03%)

*$p = 0.02$; **$p = 0.03$; ***$p = 0.001$.
HA = hand-assisted; LN = laparoscopic nephrectomy.

Table 2: Reasons for reoperation by experience and LN technique

	Center's LN experience (n)	HA LN (n)	Non-HA LN (n)
Bleeding	>50	1	5
	25	2	5
	<25–50	1	2
Bowel obstruction	>50	2	–
	<25	1	3
	25–50	3	–
Bowel injury	>50	–	2
	<25	2	–
	25–50	–	2
Hernia	>50	1	–
	<25	3	–
	25–50	5	1

HA = hand-assisted; LN = laparoscopic nephrectomy.

Table 3: Postoperative complications not requiring reoperation, by donation technique

	Open (n = 5660)	HA LN (n = 2239)	Non-HA LN (n = 2929)
Bleeding*	4 (0.1%)	10 (0.45%)	6 (0.2%)
Rhabdomyolysis**	–	2 (0.09%)	4 (0.13%)
Deep vein thrombosis/pulmonary embolus	1 (0.02%)	2 (0.09%)	3 (0.1%)
Prolonged ileus	–	1 (0.05%)	2 (0.06%)
Pneumothorax	4 (0.09%)	1 (0.05%)	–
Other	10 (0.18%)	6 (0.27%)	9 (0.3%)
Total***	19 (00.3%)	22 (1%)	24 (00.8%)

*p = 0.03; **p = 0.001; ***p = 0.02.
HA = hand-assisted; LN = laparoscopic nephrectomy.

Table 4: Complications by experience and LN technique

	Center's LN experience (n)	HA LN (n)	Non-HA LN (n)
Bleeding	>50	4	2
	<25	1	–
	25–50	4	4
Rhabdomyolysis	>50	–	–
	<25	2	–
	25–50	–	3

HA = hand-assisted; LN = laparoscopic nephrectomy.

Table 5: Reasons for readmissions, by donation technique

	Open (n = 5660)	All LN (n = 5168)	p
Nausea and vomiting, dehydration, ileus	5	28	0.001
Constipation	–	7	0.006
Diarrhea	–	1	NS
Wound (infection/dehiscence)	7	4	NS
Reoperation			
Small bowel obstruction	2	3	NS
Hernia	10	6	
Other	12	18	NS
Total	36 (0.6%)	67 (1.3%)	0.001

LN = laparoscopic nephrectomy; NS = not statistically significant.

Table 6: Readmissions after LN, by technique

	HA LN (n)	Non-HA LN (n)	Unspecified (n)
Nausea and vomiting, dehydration, ileus	13	11	3
Constipation	2	3	2
Diarrhea	–	1	–
Wound	1	3	
Small bowel obstruction	1	3	
Hernia	5	–	

HA = hand-assisted.

unrelated donor transplants is similar to outcome after non-HLA-identical living related donor transplants (11,12). Acceptance of unrelated donors significantly increases the potential donor pool. Third, LN is now an attractive option, so more recipients appear to be more receptive to accepting an LD kidney (5).

The major disadvantage of LD transplants is the risk to the donor: both the operative risk and the long-term risk of living with one kidney. The operative risk has previously been described for open nephrectomy. Perioperative mortality is 0.03% (6,7); complications, mostly minor, occur in $<10\%$ of donors (13). To date, follow-up studies have not shown increased long-term risk after open nephrectomy (6,14), but it is recognized that some donors have eventually developed renal failure (15).

Our current survey also suggests that, with the introduction of LN, perioperative mortality is unchanged from a decade ago. Of 10 828 donors between January 1, 1999, and July 1, 2001, two have died and one is in a persistent vegetative state (a total of 0.03%). A concern is that all three of these donors had undergone LN. Certainly, the intraoperative bleed and the 'unspecified' case may have been related to the surgical technique. But the third problem, fatal pulmonary embolus, has been reported after open nephrectomy; in fact, it was the most common cause of death in a previous survey (6).

To date, reoperation was carried out in $<1\%$ of all donor nephrectomy cases. Although we noted a statistically significant difference in reoperation rates between the two techniques, the difference was small. Reasons for reoperation did differ. Bleeding was a more common etiology with non-HA LN donors; bowel obstruction, with HA LN donors; and hernia, with HA LN and open nephrectomy donors. It is unknown whether additional LN experience will result in lower reoperation rates. Our data would suggest that complications occurred in centers with both a large and small experience. In addition, in centers with a large experience, complications occurred late as well as early. However, we did not differentiate between a center's experience and an individual surgeon's experience. It may be that some complications occurring late in centers with a large experience actually were early in an individual surgeon's experience. One difference that will persist is that LN is an intraperitoneal operation whereas open nephrectomy is a retroperitoneal operation (although retroperitoneal LN has been described [16]). Thus, the risk of requiring reoperation for bowel obstruction, although small, will likely be higher with LN than with open nephrectomy. This possibility should be discussed with potential donors.

We noted significantly more readmissions after LN (vs. open nephrectomy). Rather than reflecting an increased complication rate, this difference may reflect attempts to shorten the hospital stay for LN donors. Numerous studies have demonstrated that LN donors require less pain medication and have a shorter hospital stay than open nephrectomy donors (4,17). It may be that a slightly increased readmission rate for a small number of donors will ultimately be an acceptable outcome in exchange for a shorter hospital stay for the majority. Future studies could resolve this question by looking at total hospitalization time.

Only five responding centers (3%) reported ≥ 1 donor having trouble obtaining health insurance or life insurance. For three centers, this problem was easily resolved. In all, only two donors were actually denied insurance: one of them was eventually covered under a spouse's policy. Spital et al. previously reported on the willingness of almost all insurance companies to provide health insurance or life insurance to donors, without increased rates (18). Our survey supports their findings.

We recognize that our study has the inherent weakness associated with a retrospective survey. First, only 73% of centers (representing 85% of transplants) responded. It is possible that centers with more complications were less likely to respond to the survey, and thus we may have underestimated the complication rate. Second, we asked open-ended questions about reoperation, complications, and readmissions. Whereas 'reoperation' and 'readmissions' are relatively specific, 'complications' may have been interpreted differently by different centers. Third, we did not ask about laterality of the kidneys removed. We believe that a well-designed prospective study will be able to address these issues. We support the establishment of an LD registry to track both short- and long-term consequences (e.g. death, need for a transplant, renal function, readmissions, complications) of donor nephrectomy (19).

In summary, morbidity and mortality after donor nephrectomy remain low. Our survey found some differences between donation techniques in the rates of reoperation, complications, and readmissions — all higher with LN. But for each technique, each of these three rates was $\leq 1.3\%$. Importantly, unlike other surgical patients, organ donors undergo an operation without any anticipation of physical benefit. It is essential that the risks be clearly explained to potential donors. Our survey provides current data from which comprehensive informed consent can be obtained from donors.

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References

1. 2001 Annual Report. Vol. 1. Richmond, VA: United Network for Organ Sharing, 2002: 32.
2. 2001 Annual Report of the US Organ Procurement and Transplantation Network and the Scientific Registry for Transplant Recipients: Transplant Data 1991–2000. Rockville, MD: Department of Heath and Human Services, Health Resources and Services Administration, Office of Special Programs, Division of Transplantation; Ann Arbor, MI: United Network for Organ Sharing; Richmond, VA: University Renal Research and Education Association.
3. Flowers JL, Jacobs S, Cho E et al. Comparison of open and laparoscopic live donor nephrectomy. Ann Surg 1997; 226 (4): 483–489.
4. Wolf JS Jr, Merion RM, Leichtman AB et al. Randomized controlled trial of hand-assisted laparoscopic versus open surgical live donor nephrectomy. Transplantation 2001; 72 (2): 284–290.
5. Schweitzer EJ, Wilson J, Jacobs S et al. Increased rates of donation with laparoscopic donor nephrectomy. Ann Surg 2000; 232 (2): 392–400.
6. Najarian JS, Chavers BM, McHugh LE, Matas AJ. 20 years or more of follow-up of living kidney donors. Lancet 1992; 340 (8823): 807–810.
7. Bia MJ, Ramos EL, Danovitch GM et al. Evaluation of living renal donors. The current practice of US transplant centers. Transplantation 1995; 60 (4): 322–327.
8. Cecka JM. The UNOS Scientific Renal Transplant Registry – 2000. In: Cecka JM, Terasaki PI (eds) Clinical Transplants. Los Angeles: UCLA Immunogenetics Center, 2001: 1–18.
9. Cosio FG, Alamir A, Yim S et al. Patient survival after renal transplantation. I. The impact of dialysis pre-transplant. Kidney Int 1998; 53 (3): 767–772.
10. Mange KC, Joffe MM, Feldman HI. Effect of the use or nonuse of long-term dialysis on the subsequent survival of renal transplants from living donors. N Engl J. Med 2001; 344(10): 726–731.
11. Terasaki PI, Cecka JM, Gjertson DW, Takemoto S. High survival rates of kidney transplants from spousal and living unrelated donors. N Engl J Med 1995; 333 (6): 333–336.
12. Terasaki PI, Cecka JM, Gjertson DW, Cho YW. Spousal and other living renal donor transplants. Clin Transpl 1997: 269– 284.
13. Johnson EM, Remucal MJ, Gillingham KJ, Dahms RA, Najarian JS, Matas AJ. Complications and risks of living donor nephrectomy. Transplantation 1997; 64 (8): 1124–1128.
14. Kasiske BL, Ma JZ, Louis TA, Swan SK. Long-term effects of reduced renal mass in humans. Kidney Int 1995; 48(3): 814–819.
15. Ellison MD, McBride MA, Turanto SE, Delmonico FL, Kaufman M. Living renal donation: When transplant donors become transplant candidates. Am J Transplantation 2002; 2 (53): 226.
16. Wadstrom J, Lindstrom P. Hand-assisted retroperitoneoscopic living-donor nephrectomy: initial 10 cases. Transplantation 2002; 73 (11): 1839–1840.
17. Kuo PC, Johnson LB. Laparoscopic donor nephrectomy increases the supply of living donor kidneys: a center-specific microeconomic analysis. Transplantation 2000; 69(10): 2211–2213.
18. Spital A, Kokmen T. Health insurance for kidney donors: how easy is it to obtain? Transplantation 1996; 62 (9): 1356–1358.
19. Abecassis M, Adams M, Adams P et al. for The Live Organ Donor Consensus Group. Consensus statement on the live organ donor. JAMA 2000; 284 (22): 2919–2926.