# Expanding the Donor Pool: Living Donor Nephrectomy in the Elderly and the Overweight

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**Background.** Increasing demand for donor kidneys, in parallel with trends toward more elderly and obese populations, make it important to continuously review donor pool inclusion criteria. Acceptance of elderly and obese living donors remains controversial, with a higher incidence of comorbidity and the greater risk of postoperative complications sighted as reasons for caution. Drawing on our center's experience, we aim to determine whether older age and obesity are in fact associated with greater perioperative risk, and longer term complications in donors undergoing nephrectomy.

**Methods.** Three hundred eighty-three living donor nephrectomies conducted at one of the United Kingdom's largest transplant units over the last 5 years were stratified into groups according to age and body mass index. Perioperative endpoints and postdonation follow-up data collected at 6-to-12-monthly intervals were analyzed and compared.

**Results.** No significant differences in operative parameters, including operative time and estimated blood loss, were reported between groups. Rates of early postoperative complications were not significantly different, although subgroup analysis showed a higher incidence of respiratory complications at the extremes of obesity (body mass index $\geq$40 kg/m$^2$). On follow-up, renal function parameters showed significant change postnephrectomy, but between-group variation was not significant. Mortality and major complication rates were comparably low in all groups of study.

**Conclusions.** In our unit's experience, nephrectomy in selected donors who may otherwise have been precluded from participation on account of their age or weight, is feasible and associated with perioperative and longer term outcomes comparable with their younger nonobese counterparts. It provides a basis for informed consent of "extended criteria" donors.

**Keywords:** Donor, Marginal, Kidney, Elderly, Overweight.

*(Transplantation* 2012;93: 1158–1165)

Kidney transplantation has become the preferred treatment in end-stage renal disease (ESRD). More than 6500 patients are currently on the UK waiting list for kidney transplantation, with many likely to die before a suitable organ becomes available (*1*). Although demand for kidney transplantation continues to rise in association with the rising prevalence of ESRD, the number of deceased donor kidneys remains static (*2*). Living-donor transplantation programs are not only crucial if we are to tackle the organ shortfall but are also known to carry superior graft outcomes when compared with deceased-donor transplantation (*3*).

Efforts to increase the number of living-donor kidney transplantations have included match-paired donation, the use of incompatible kidneys, pooled donation, and attempts at changing the legislation surrounding organ donation. Another approach has been to look at the feasibility of expanding donor criteria to include individuals previously deemed unsuitable.

In the early stages of the live donor program, advanced age and donor obesity were considered absolute contraindications to donation as these factors were deemed to put donors at higher risk of perioperative and longer term morbidity and mortality. But with rising demand for organs, with increasingly elderly and overweight populations, and with advances in the field of transplantation, it is becoming critical to continually review the validity of these exclusions.

The authors declare no funding or conflicts of interest.

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B.B., S.M., and A.S. participated in research design, in the writing of the manuscript, and in data analysis; N.H. participated in research design and in data accumulation; D.T. participated in research design and in data accumulation; and V.P. participated in research design and in data accumulation.

Received 10 October 2011. Revision requested 26 October 2011.
Accepted 16 January 2012.

ISSN: 0041-1337/12/9311-1158
DOI: 10.1097/TP.0b013e31824ef1ae

Donor obesity, though still generally considered a relative contraindication, has more recently been shown to be compatible with acceptable donor and graft outcomes in the majority of cases (*4–7*). UK guidelines have supported the use of otherwise healthy overweight and moderately obese donors (body mass index [BMI] 25–35 kg/m$^2$). When it comes to "very obese" donors (BMI≥35 kg/m$^2$), guidelines are more ambiguous, and this reflects the fact that data on the safety of donation in these individuals are limited (*4*).

Donors of older age are unsurprisingly more likely to be excluded from donating as a consequence of other comorbidities. If however, after rigorous preoperative assessment, the potential donor is deemed fit, some researchers have shown there to be no compelling evidence for exclusion based on age alone (*4*). Indeed, some studies have shown survival outcomes in the elderly donor to be superior to those of matched controls (*8*). There exists though, a lack of consensus, with other groups reporting a higher incidence of postoperative complications, longer hospital stays, and poorer overall graft survival rates (*9, 10*).

Living donor nephrectomy (LDN) is a safe procedure with an estimated mortality of 0.03% (*6*). Although careful donor selection is essential in ensuring these levels of safety, stringent selection guidelines may also serve to limit the scarce organ pool. Operating on a healthy cohort of individuals without conferring on them a health benefit must, equally, cause them no harm. It is also important to remember that donors often take great psychological reward from the opportunity to drastically improve the quality of life of a partner, relative, friend, or even stranger—some find it extremely distressing when deemed unsuitable to donate. In the knowledge that obesity and old age are associated with increased risk of adverse renal function in the long term, it becomes clear that transplant teams and potential donors face a difficult decision. With population obesity on the rise, such decisions have to be made with increasing regularity.

In an effort to aid such decisions, we draw on our transplant center's experience to look at the feasibility of LDN at the upper extremes of age and BMI. We aim to compare the perioperative and longer term outcomes in these patients when compared with younger, nonobese donors.

## RESULTS

Preoperative demographic characteristics of all groups of study are shown in Table 1. At donation, the mean age of the 383 live donors was 46±12.7 years, with similar proportions of male and female donors (1:1.2). Age and BMI characteristics of each study group are illustrated in Figure 1. Both elderly I and elderly II groups had a significantly greater percentage of individuals with recognized and treated hypertension, whereas baseline systolic blood pressure was significantly greater in elderly II when compared with the reference group (147.8±17.7 vs. 132.2±15.9 mm Hg). The elderly and obese group exhibited a greater proportion of treated hypertension, a higher baseline systolic blood pressure, and was the only group to show significantly lower estimated glomerular filtration rate (eGFR), when compared with the reference group (62.7±10.9 vs. 85.8±18.6 mL/min/1.73 m$^2$).

The obese I and obese II groups required marginally longer operating times on average than did the reference group (10.9 and 16.1 min longer, respectively), though these differences were not statistically significant. There were no significant differences between the groups in terms of estimated

**TABLE 1.** Living-donor baseline clinical characteristics by study group

| | Study group | | | | | |
|---|---|---|---|---|---|---|
| | Reference group | Elderly group I | Elderly group II | Obese group I | Obese group II | Elderly and obese group |
| N | 205 | 29 | 21 | 62 | 28 | 8 |
| Age (yr) | 42.3±10.4 | 62.0±1.5[a] | 68.2±2.6[a] | 41.7±10.4 | 43.7±9.0 | 64.25±4.8[a] |
| BMI (kg/m$^2$) | 24.9±2.8 | 25.5±2.8 | 25.3±3.1 | 31.9±1.2[a] | 38.0±3.4[a] | 33.8±2.9[a] |
| Male (%) | 45.4 | 55.2 | 52.4 | 40.3 | 50.0 | 25.0 |
| Race (%) | | | | | | |
| White | 62 | 72 | 85 | 52 | 75 | 75 |
| Asian | 21 | 17 | 14 | 23 | 7 | 25 |
| Black | 13 | 3 | 0 | 21 | 7 | 0 |
| Other | 4 | 9 | 0 | 5 | 11 | 0 |
| Systolic BP (mm Hg) | 132.2±15.9 | 139.1±32.2 | 147.8±17.7[a] | 135.2±16.7 | 132.42±14.6 | 146.6±20.0[a] |
| Diastolic BP (mm Hg) | 80.0±9.1 | 83.6±12.7 | 80.5±12.6 | 82.5±11.0 | 82.9±8.5 | 81.0±9.2 |
| Recognized and treated hypertension (%) | 8.5 | 25.0[a] | 30.0[a] | 10.9 | 3.8 | 14.3 |
| Family history of diabetes (% yes) | 15.1 | 12.0 | 6.2 | 16.0 | 17.4 | 28.6[a] |
| MDRD-eGFR (mL/min/1.73 m$^2$) | 85.8±18.6 | 82.0±16.9 | 78.0±18.7 | 84.0±15.7 | 82.0±13.9 | 62.7±10.9[a] |
| Serum creatinine (μmol/L) | 109.7±28.8 | 106.1±18.0 | 97.9±20.6 | 117.3±31.4 | 139.9±41.7 | 90.6±10.6 |

[a] *P* value <0.05 and therefore significantly different in relation to reference group.
Data expressed as mean±SD.
NS, not significant; BP, blood pressure; MDRD, modification of diet in renal disease; eGFR, estimated glomerular filtration rate.

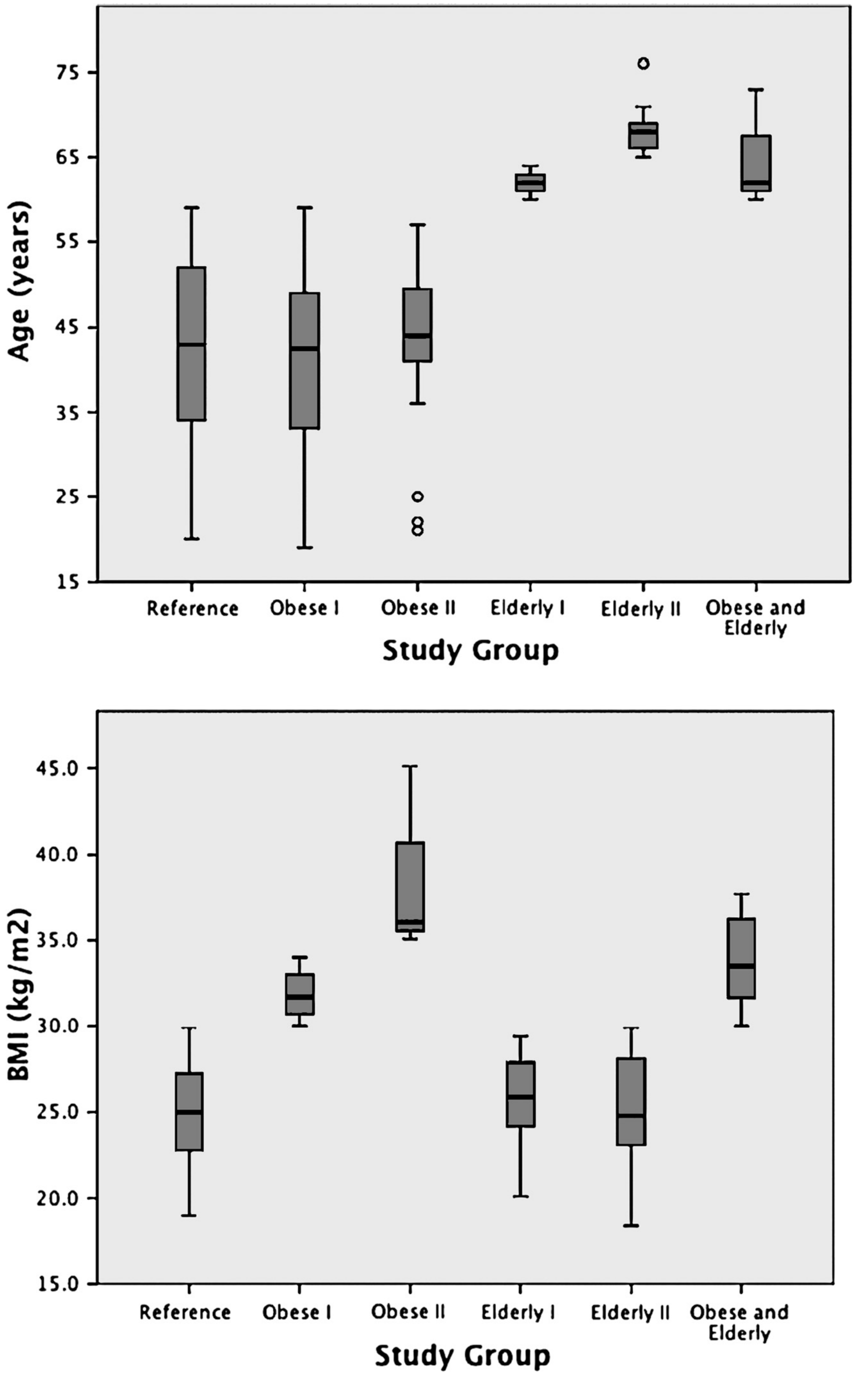


**FIGURE 1.** Age and body mass index (BMI) characteristics of all groups of study.

operative blood loss, or indeed postoperative length of hospital stay. Table 2 provides a summary of these perioperative parameters.

In the 383 nephrectomies conducted, no instances required reoperation, and no major complications or deaths were encountered. As shown in Table 3, pneumonia, postoperative fever of unknown origin, and wound infection accounted for the majority of postoperative complications. These rates are in keeping with results from other centers and studies (*11*). Rates of complications were, however, not found to be significantly different between the groups of study. Subgroup analysis showed that, at the extremes of obesity, in the seven patients with a BMI more than 40 kg/m$^2$, a higher incidence of respiratory complications was encountered with 57% requiring antibiotic therapy for suspected pneumonia ($P<0.01$). None required ventilatory support and all recovered without sequelae.

Mean length of follow-up was 20.5±16.3 months and did not vary significantly between groups. Some individuals had missing data at one or multiple of the follow-up time-points;

**TABLE 2.** Operative parameters and length of hospital stay

| | Study group | | | | | |
|---|---|---|---|---|---|---|
| | Reference group | Elderly group I | Elderly group II | Obese group I | Obese group II | Elderly and obese group |
| Kidney removed (% left) | 87 | 100.0 | 88.9 | 90.9 | 93.8 | 100.0 |
| Operative time (min) | 125.3±47.8 | 135.7±71.3 (NS) | 113.6±49.9 (NS) | 136.2±48.7 (NS) | 141.4±54.8 (NS) | Insufficient data |
| Estimated blood loss (mL) | 128.6±62.9 | 180.0±106.1 (NS) | 108.3±24.0 (NS) | 141.82±94 (NS) | 166.6±106.1 (NS) | Insufficient data |
| Length of postoperative hospital stay (d) | 4.9±1.3 | 4.3±0.5 (NS) | 5.7±1.3 (NS) | 5.2±1.4 (NS) | 5.3±1.4 (NS) | 5.3±1.5 (NS) |

**TABLE 3.** Complications after donor nephrectomy

| | Study group | | | | | |
|---|---|---|---|---|---|---|
| | Reference group | Elderly group I | Elderly group II | Obese group I | Obese group II | Elderly and obese group |
| No complications (% of group total) | 71.7 | 78.3 | 77.8 | 64.3 | 73.1 | 85.7 |
| Respiratory tract infection (% of group total) | 8.2 | 8.7 | 5.6 | 5.4 | 11.5 | 14.3 |
| Pyrexia (unknown etiology) (% of group total) | 9.8 | 4.3 | 5.6 | 7.1 | — | — |
| Wound infection (% of group total) | 4.3 | 8.7 | — | 10.7 | 3.8 | — |
| Urinary tract infection (% of group total) | 1.6 | — | — | — | — | — |
| Pleural effusion (% of group total) | 1.1 | — | — | — | — | — |
| Ilius (% of group total) | 0.5 | — | — | — | 3.8 | — |
| Atelectasis (% of group total) | — | — | — | 1.8 | 7.7 | — |
| Pulmonary embolous (% of group total) | — | — | — | 1.8 | — | — |
| Reoperation (% of group total) | — | — | — | — | — | — |
| Mortality (% of group total) | — | — | — | — | — | — |
| Other (% of group total) | 2.7 | — | 11.1 | 8.9 | — | — |

however, the proportion of donors with missing data did not vary significantly across donor categories. Analysis of our follow-up data shows all groups to exhibit a significant post-nephrectomy fall in modification of diet in renal disease-eGFR and rise in serum creatinine, with a partial recovery over the follow-up period toward baseline. Repeated measures analysis of variance confirms this within-group variation, but also indicates that variation between-groups is not significant ($P$>0.28 between all groups when compared with reference group). Put differently, although all groups experienced significant changes in renal parameters after nephrectomy, the pattern of change was similar for all groups. Figure 2 illustrates these results.

Systolic blood pressure was significantly higher in the elderly groups prenephrectomy and continued to be so 2 years postnephrectomy as compared with the reference group. Systolic pressure was also significantly higher in the elderly and obese group during the majority of follow-up. Of all donors, 2.1% developed new onset hypertension over a 3-year period, with our results not indicating any variations between groups. New onset diabetes mellitus affected 2.8% of the study population, with the obese group being significantly more likely to be affected ($P$<0.01). This higher incidence of diabetes in obese donors is in keeping with the higher incidence experienced by the general, "two kidney" obese population.

## DISCUSSION

Our center's experience with living-donors at the extreme of age and BMI adds valuable data to the ongoing effort of assessing the safety of nephrectomy in these individuals. Our data show the operative safety and follow-up outcomes of uninephrectomy in these donors to be acceptable and comparable with their younger nonobese counterparts.

Intraoperative outcomes including operative time and estimated blood loss were marginally increased in obese groups, though not significantly so. These findings are corroborated by other researchers (*5*, *12*). In a recent systematic review by Young et al. (*12*) and meta-analysis of six studies, the pooled estimate of the mean increase in blood loss amounted to 57 mL, whereas that of operative time to 20 min. It is fair to assume the clinical significance of these results to be minimal. The effect of older age on these parameters was also statistically and clinically insignificant

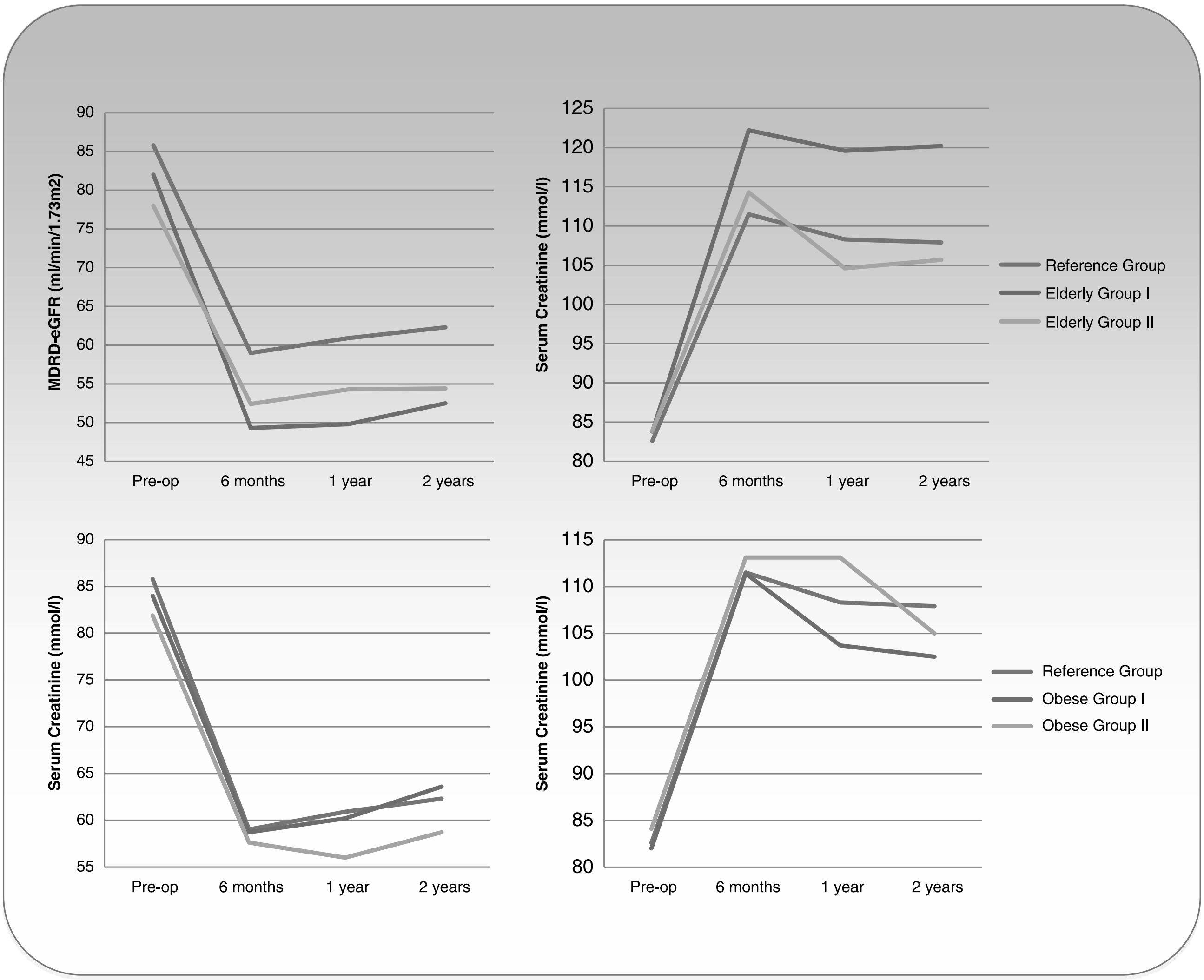


**FIGURE 2.** Estimated glomerular filtration rate (eGFR) and serum creatinine pre- and postnephrectomy.

in our sample, something further supported by evidence from other groups (*12, 13*).

The length of hospital stay experienced by donors at our center was comparably low across all BMI and age groups and, although Friedman et al. (*9*) found a statistically significant increase in hospital stay in their analysis of 6320 donors, the increase amounted to only 0.3 and 0.2 days in the obese and those older than 50 years, respectively. Our groups of study were at greater extremes of age and BMI, yet the increase in mean length of stay experienced was similar to the low levels described by Friedman's group.

Little consensus exists in the literature with regard to the influence of greater age and BMI on minor postoperative complication rates. Fauchald et al. (*14*) report greater rates of cardiac complications and pneumonia in donors older than 60 years. Friedman's group support these data and suggest that postoperative complications affect 22.9% of donors older than 50 years as opposed to only 16.8% of donors younger than 30 years (*9*). Regarding obese donors, Heimbach et al. (*5*) found those with BMI more than or equal to 35 kg/m$^2$ to suffer more minor complications, wound infections in particular, than did their nonobese counterparts, with other researchers also supporting these findings (*9*). Our data, however, show there to be no significant variation in minor complication rates between the groups of study. Hsu et al. (*15*) also report good outcomes after nephrectomy in their group of six donors with mean age 69.5 years, as do Jacobs et al. (*13*) in their larger series of 738 nephrectomies conducted in Maryland (Table 4). Despite having found obesity and older age to be associated with greater risks of perioperative complications (odds ratio=1.92, and odds ratio=1.81, respectively), another unit have drawn the fair conclusion that "these findings hardly warrant the exclusion of donors with these identifiable risk factors, especially because the overall risk is quite minimal" (*10*). In light of the aforementioned lack of consensus and minor nature of the complications involved, we would tend to agree. More importantly, that surgical mortality and major morbidity after nephrectomy remain at comparable low levels across age and BMI categories is well described, and holds true in our dataset (*5, 6*).

Regarding longer term follow-up outcomes, a number of groups have shown renal parameters to be significantly

**TABLE 4.** Postnephrectomy outcomes by study group

| | Study group | | | | | |
|---|---|---|---|---|---|---|
| | Reference group | Elderly group I | Elderly group II | Obese group I | Obese group II | Elderly and obese group |
| MDRD-eGFR (mL/min/1.73 $m^2$) | | | | | | |
| Prenephrectomy | 85.8±18.1 | 82.0±13.9 | 78.0±18.7 | 84.0±15.6 | 81.9±13.9 | 62.7±11.0[a] |
| 6 mo postoperative | 59.0±12.0 | 49.3±9.6[a] | 52.4±6.1[a] | 58.7±10.4 | 57.6±10.5 | 43.5±7.6[a] |
| 1 yr postoperative | 60.9±11.6 | 49.8±8.3[a] | 54.3±6.2[a] | 60.2±11.0 | 56.0±10.0 | 43.3±9.0[a] |
| 2 yr postoperative | 62.3±10.8 | 52.5±11.4 | 54.4±7.2 | 63.6±12.6 | 58.7±10.9 | 34.0±5.6 |
| % fall from baseline at 2 yr | 27.4 | 35.9 | 30.3 | 24.3 | 28.3 | 45.8 |
| Serum creatinine (μmol/L) | | | | | | |
| Prenephrectomy | 82.6±15.0 | 83.8±14.9 | 83.9±12.0 | 82.0±11.8 | 84.1±10.8 | 89.1±12.3 |
| 6 mo postoperative | 111.5±20.9 | 122.2±24.1[a] | 114.3±26.1 | 111.4±20.1 | 113.1±21.5 | 118.0±21.1 |
| 1 yr postoperative | 108.3±20.0 | 119.6±27.6 | 104.6±27.6 | 103.7±17.3 | 113.1±20.7 | 116.7±24.7 |
| 2 yr postoperative | 107.9±22.3 | 120.2±24.4 | 105.7±12.7 | 102.5±15.0 | 105.0±16.4 | 129.7±37.5 |
| % rise from baseline at 2 yr | 30.6 | 43.4 | 26.0 | 25 | 24.9 | 45.6 |
| Systolic BP (mm Hg) | | | | | | |
| Prenephrectomy | 132.2±16.0 | 139.1±32.2 | 147.8±17.7[a] | 135.2±16.7 | 132.4±14.5 | 146.6±20.0[a] |
| 6 mo postoperative | 130.6±16.1 | 140.9±21.3[a] | 145.1±22.6[a] | 135.5±15.6 | 132.5±11.9 | 140.4±20.8 |
| 1 yr postoperative | 129.4±16.8 | 137.5±27.4 | 142.4±15.0[a] | 134.4±19.1 | 133.9±12.0 | 145.0±13.2[a] |
| 2 yr postoperative | 130.1±14.8 | 149.4±27.9[a] | 142.8±21.5[a] | 131.5±13.7 | 133.1±12.3 | 148.7±27.2 |
| Diastolic BP (mm Hg) | | | | | | |
| Prenephrectomy | 80.0±9.1 | 83.6±12.7 | 80.5±12.7 | 82.5±11.1 | 82.9±8.5 | 81.0±9.2 |
| 6 mo postoperative | 79.5±9.8 | 79.8±11.1 | 79.4±11.2 | 80.6±10.9 | 82.7±8.2 | 81.4±6.9 |
| 1 yr postoperative | 79.8±10.5 | 79.6±12.3 | 80.8±10.3 | 81.9±11.2 | 81.7±7.4 | 86.1±12.9 |
| 2 yr postoperative | 78.6±10.3 | 84.9±10.6 | 79.5±11.1 | 82.0±13.4 | 83.7±4.1 | 84.3±7.6 |

[a] *P* value <0.05 and therefore significantly different in relation to reference group.
Data expressed as mean±SD.
BP, blood pressure; MDRD, modification of diet in renal disease; eGFR, estimated glomerular filtration rate.

affected after uninephrectomy with, for instance, reductions in GFR of anywhere between 20% and 40% (*16, 17*). Certain research groups have found that a significant proportion of kidney donors, whether elderly, obese or neither, show a fall in GFR less than 60 mL/min/1.73 $m^2$, and so can be classified as suffering from chronic kidney disease (*18, 19*). In our data, this was true of between 10% and 20% of each of our groups of study. It is important to note, however, that the clinical significance of a GFR less than 60 mL/min/1.73 $m^2$ in a single healthy kidney may not be equivalent to a subject of similar renal function with two diseased kidneys (*20*). After the initial decline of GFR postnephrectomy, the processes of renal hypertrophy and other possible compensatory mechanisms are little understood. Reese et al. (*21*) show that these changes in renal function parameters follow a similar pattern across BMI groups in that the percentage change from baseline is not significantly different between groups. Our data are in keeping with these findings in that they too show deterioration in renal function parameters across all groups of study after nephrectomy, but with a pattern of change not significantly different between BMI and age groups.

Crucially, despite the recognized affects of uninephrectomy on renal parameters such as GFR, numerous groups have shown that clinical outcomes over long-term follow-up periods are encouraging, and comparable with their two-kidney counterparts (*6, 22, 23*). Incidence of ESRD is similar to that of the general population (*24*). Blood pressure has in fact been shown to be lower in donors than it is in the general population (*17*). Indeed, Fehrman-Ekholm et al. (*25*) have argued that kidney donors live longer than their general population counterparts.

It would be reasonable to assume that because older age and higher BMI in themselves represent greater risks for developing hypertension, heart disease, and hypercholesterolemia, and because chronic kidney disease can further contribute to the likelihood of developing these, then to combine the two by offering obese and elderly individuals nephrectomies would be to endanger donors too greatly. But this does not pan out in the data, in fact any increase in the incidence of hypertension and other cardiovascular risk factors seen in obese donors is attributable to obesity in isolation, and not further exacerbated by nephrectomy per se (*7*). Though similar data does not exist for elderly donors, article by Berger et al. (*8*) shows 10-year survival in elderly donors to be far superior to the general population (90% vs. 73%) is somewhat encouraging.

Finally and though not falling within the scope of data presented herein, it is important to remember the recipient in the transplantation equation. Again, accounts are conflicting. Some researchers show grafts from elderly and obese donors to have similar outcomes as their younger, nonobese counterparts (*12, 14, 26*), whereas others show grafts from marginal donors to carry inferior recipient outcomes (*8, 27*). With the considerable morbidity and mortality associated with being on the waiting list, and with half of all transplant candidates older than 60 years of age dying before receiving a transplant, perhaps it might be said that a marginal graft is better than no graft at all (*1*).

Although obese donors (BMI≥30) account for more than 20% and elderly donors (age≥50 years) for another 20% of LDNs in some countries (*6*), a number of researchers have highlighted a paucity of data relating to the extremes of age and BMI. Despite of substantial limitations, our center's experience of uninephrectomy in those of BMI more than or equal to 35 and age more than or equal to 65 adds valuable data to the ongoing effort of assessing the feasibility and safety of donation in such cases.

Regarding these limitations, first, our assessment of renal function did not include a direct measure of GFR. This is not something routinely conducted during our follow-up of donors, and so could not form part of the data analysis. Although 24-hr protein and urinary protein-to-creatinine ratios were conducted on some of our donors, compliance was low and data collection too sparse over the follow-up period to provide meaningful results. Second, the early data we present cannot substitute for long-term follow-up of donors over decades rather than years. We hope results from this study can contribute and provide some impetus to the development of larger multicenter investigations in order both to amass data from greater donor numbers, but to provide longer follow-up results for analysis. Third, it is difficult to account for an institutional learning curve, save to say that all patients have been operated on by a group of just three surgeons, all of whom had many years of experience in this procedure before commencement of the study in 2005. Finally, our results are inevitably center specific. As one of the largest kidney transplant units in the United Kingdom, the volume of nephrectomies is greater and this has been associated with improved outcomes (*9*). In addition, the hand-assisted mini-open nephrectomy is not ubiquitously used, with many European centers continuing to use traditional open or laparoscopic techniques (*28*).

Despite these limitations, we believe our data to support the cautious acceptance of elderly and obese individuals meeting rigorous selection criteria as potential donors. We hope our data will form part of the literature used in making decisions as to donor suitability, and in counseling these individuals before they embark on what is inevitably a procedure that carries an element of risk. Though we are reluctant to promote the widespread use of expanded criteria donors until more extensive data acquisition and analysis has occurred, we believe our results on the safety and feasibility of this procedure are nevertheless encouraging.

## MATERIALS AND METHODS

This study involves a retrospective review of the medical records of living kidney donors undergoing nephrectomy at the West London Renal and Transplant Centre between January 2005 and June 2010.

Donor selection and acceptance for nephrectomy was not guided by this study's procedures, but rather the clinical and ethical decisions made by the transplant team based on their understanding of the prevailing standard of care at that time. The team variously consisted of transplant surgeons, nephrologists, nurse specialists and anesthetists, and received guidance from the center's medical ethics division. No firm rule regarding the degree of advancing age or obesity constituting an absolute contraindication for donation is in place at our organization, each case is treated individually and in light of a number of preoperative assessment outcomes. All potential donors receive rigorous evaluation, which includes blood pressure measurement, physical examination, extensive laboratory testing including HbA1c, fasting glucose, lipid profile, full blood count, serum creatinine, 24-hr urinary protein collection, urinalysis, virology and infection screens, imaging including magnetic resonance angiography, cardiorespiratory testing including exercise tolerance tests, and psychological assessment. Exclusion criteria were not fixed, but rather assessed on a case-by-case basis and included age less than 18 years, evidence of renal disease, evidence of significant cardiac disease, specific viral infections, substance abuse, and psychiatric illness. All nephrectomies conducted at our center are carried out by the hand-assisted mini-open nephrectomy technique, which has been previously described in detail (*28–30*).

After the immediate in-patient recovery period, regular follow-up was arranged at 6 months and 1 year postnephrectomy, and then annually thereafter. Our follow-up clinic protocol includes taking a complete history with psychosocial assessment of the donor and full physical examination. We also record basic parameters such as weight and blood pressure measures, and conduct laboratory investigations including renal function and filtration rate tests. Any conditions of new onset, for example diabetes and hypertension, were noted and analyzed. Based on information from their records, donors were divided into groups according to BMI and age:

1. A *reference group* that included donors who are neither at the extremes of age or BMI (18≤age≤60, and 20≤BMI≤30)
2. Two groups of elderly, nonobese donors stratified by age
   a. Elderly I group: (60≤age≤65, and 20≤BMI≤30)
   b. Elderly II group: (age≥65, and 20≤BMI≤30)
3. Two groups of obese, nonelderly donors stratified by BMI
   a. Obese I group: (30≤BMI≤35, and 18≤age≤60)
   b. Obese II group: (BMI≥35, and 18≤age≤60)
4. An elderly and obese group: (BMI≥30, and age≥60)

To avoid definitional contention as to what constitutes a "marginal" or "extended criteria" donor, our main focus of interest lay with the obese II and elderly II groups. We believe these groups to be universally accepted as representing marginal donors. The obese I and elderly I groups are groups that are more commonly considered for nephrectomy in many units, and in this study served primarily as a point of comparison. Those not falling under these groups were excluded from study.

Demographic data were collected for all donors including gender, age, ethnicity, and BMI. We analyzed two sets of primary outcomes, namely perioperative and longer term follow-up measures. Perioperative measures included intraoperative time, estimated intraoperative blood loss, length of hospital stay, and incidence of surgical complications and mortality. Follow-up measures aimed to assess the effect of nephrectomy on longer term donor renal function. We analyzed and compared pre- and postoperative changes in blood pressure, GFR, and creatinine clearance.

GFR was calculated using the four-variable modification of diet in renal disease equation, which has been shown to give a consistent estimation of GFR across categories of BMI and appropriate estimation of GFR in those older than 60 years (*31*). Data are presented as mean±SD. Where necessary, comparisons across multiple groups were conducted using analysis of variance, whereas specific group comparisons were made using Mann-Whitney *U* test. Differences in time were compared by repeated measurement analysis of variance where sphericity was met. *P* values less than 0.05 were considered significant. For statistical analyses, the SPSS software package (SPSS version 18.0.3, Chicago, IL) was used. This study has been discussed with the relevant representative of our institutional research ethics committee and formal ethical approval has been waved for this retrospective database analysis.

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