The weekend effect alters the procurement and discard rates of deceased donor kidneys in the United States

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Factors contributing to the high rate of discard among deceased donor kidneys remain poorly understood and the influence of resource limitations of weekends on kidney transplantation is unknown. To quantify this we used data from the Scientific Registry of Transplant Recipients and assembled a retrospective cohort of 181,799 deceased donor kidneys recovered for transplantation from 2000–2013. We identified the impact of the day of the week on the procurement and subsequent utilization or discard of deceased donor kidneys in the United States, as well as report the geographic variation of the impact of weekends on transplantation. Compared with weekday kidneys, organs procured on weekends were significantly more likely to be discarded than transplanted (odds ratio: 1.16; 95% confidence interval: 1.13–1.19), even after adjusting for organ quality (adjusted odds ratio: 1.13; 95% confidence interval: 1.10–1.17). Weekend discards were of a significantly higher quality than weekday discards (Kidney Donor Profile Index: 76.5% vs. 77.3%). Considerable geographic variation was noted in the proportion of transplants that occurred over the weekend. Kidneys available for transplant over the weekend were significantly more likely to be used at larger transplant centers, be shared without payback, and experienced shorter cold ischemia times. Thus, factors other than kidney quality are contributing to the discard of deceased donor kidneys, particularly during weekends. Policy prescriptions, administrative or organizational solutions within transplant programs may potentially mitigate against the recent increase in kidney discards.

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Weekends are traditionally a period of limited resources at hospitals and numerous studies have demonstrated the adverse impact of weekends on patient outcomes. For example, higher mortality rates have been observed among patients admitted on weekends for diagnoses where outcomes are associated with time-sensitive interventions, such as myocardial infarctions, strokes, and pulmonary embolism.[1–5] Similar analyses for diagnoses requiring urgent surgery, such as ruptured aortic aneurysms, have also demonstrated inferior outcomes.[6] Previous analyses have suggested that outcomes following kidney and liver transplants performed over the weekend are similar to transplants performed during the week.[7–10] However, these analyses examined only the outcomes of organs that were procured and actually transplanted without accounting for the impact of organ selection.

Each year over 5000 people die waiting for a kidney transplant, whereas annually, nearly 2700 kidneys that are procured for transplantation are subsequently discarded.[11] This high rate of discard is concerning especially given the worsening organ shortage in the United States, yet the factors contributing to organ discard remain poorly understood. Although the most commonly cited reason for organ discard is biopsy results (despite growing evidence that these findings are not predictive of outcomes), recent analyses suggest that even kidneys of acceptable quality are being discarded at an increasing rate.[9,10,12] Poor donor kidney function, anatomic abnormalities, and concern regarding donor medical/social history are other highly cited reasons for the discard of deceased donor kidneys procured for transplant.[9,13,14] It is important to note that currently no universal guidelines exist in the United States to recommend which kidneys should be utilized and which should be discarded. As a result, we hypothesize that there is a significant degree of transplant center-to-center variability, suggesting that factors external to the donor organ, or recipient, may contribute to transplant centers' decisions not to transplant an organ. However, whether resource limitations at transplant centers contribute to the discard of deceased donor kidneys has not been studied. In this study, our objective was to analyze whether the

procurement and utilization of deceased donor kidneys in the United States varied by day of the week, specifically, if it was different on weekends than on weekdays.

RESULTS

In the United States from 2000 to 2013, approximately 202,000 deceased donor kidneys were available for procurement ($n = 201,956$), of which ~90% were procured for transplant ($n = 181,799$) (Table 1, Supplementary Figure S1). The number of deaths in the United States during that period varied by day of the week and peaked on Friday and Saturday.[15] Similarly, the total number of kidneys available for procurement varied by day of the week but the highest numbers were available on Tuesdays (15.1%) and Wednesdays (15.1%), whereas the lowest numbers were available on Sunday and Monday (13.5% and 13.4%, respectively) (Table 1). The average quality of kidneys available for procurement, as measured by the Kidney Donor Profile Index (KDPI), also varied significantly by day of the week ($P < 0.001$). Fridays were associated with the lowest rate of procurement of kidneys from the available donor pool (89.3%) and the procured kidneys had the highest average KDPI (value of 53.7%), that is, the lowest quality, for kidneys procured on any single day of the week. In contrast, Sundays and Mondays were associated with having the highest rates of procurement of donor kidneys but these kidneys also had the lowest KDPI, suggesting that the procured kidneys were of a significantly better quality on average (Table 1).

Nearly 80% of kidneys transplanted on the weekend were procured from deceased donors on Fridays and Saturdays (Supplementary Table S1). Kidneys procured on Fridays experienced the highest rate of organ discard for the week (Table 1). The rate of kidney procurement on Saturday was marginally higher than that seen on Friday (89.7% vs. 89.3%, $P < 0.001$), whereas the discard rate for kidneys procured on Saturday (18.4%) was the second highest for the week after kidneys procured on Friday (18.8%). The discard rate was lowest on Monday and increased over the course of the week to peak on Friday ($P < 0.001$) (Table 1). The odds of discard of a kidney after procurement tended to increase over the course of the week (reference = Monday), that is, as the weekend neared, there was an increase in the odds of discard for kidneys procured on Friday and Saturday (Figure 1, Table 2). The quality of discards also showed an uptrend during the course of the week and peaked on Friday. As a result, the odds of kidney discard on Friday and Saturday remained significantly elevated even after adjustment for the KDPI (adjusted odds ratio [aOR]: 1.19; 95% confidence interval [CI]: 1.13–1.26; $P < 0.001$, and aOR: 1.18; 95% CI: 1.11–1.24; $P < 0.001$, respectively) (Figure 1, Table 2). The percentage of kidneys being shared without payback between donor service areas increased from Monday to a peak on Saturday ($P = 0.003$) (Table 1). Additionally, kidneys procured on weekends (Friday and Saturday) were more likely to be transplanted at larger transplant centers than kidneys procured on a weekday (Sunday–Thursday; $P = 0.037$).

When considered together, kidneys procured on Friday and Saturday, that is, kidneys available for transplant on the weekend, were much more likely to be discarded (18.6% vs. 16.4%, $P < 0.001$); these discarded kidneys were more likely to be of a higher quality, that is, lower KDPI, (76.5% vs. 77.3%, $P = 0.018$) than those discarded during the rest of the week (Table 1). Compared with weekday kidneys, organs procured for transplantation on weekends were approximately 1.2 times more likely to be discarded than transplanted (OR: 1.16; 95% CI: 1.13–1.19; $P < 0.001$), even after adjusting for organ quality (aOR: 1.13; 95% CI: 1.10–1.17; $P < 0.001$) (Table 3). Kidneys available for transplant over the weekend were also more likely to be used at larger transplant centers ($P = 0.037$), be shared without payback ($P = 0.001$), and experienced shorter cold ischemia times ($P = 0.002$) (Table 1). However, the majority of transplanted kidneys, regardless of weekday period or day of the week distinction, were transplanted the day after they were procured (Supplementary Table S2), resulting in relatively similar mean cold ischemia times (Supplementary Table S2).

Transplants performed on the weekend were not evenly distributed across the country (Figure 2). Uniform transplantation rates and preferences suggest that, on average, 28.6% (2 of 7) of all deceased donor kidney transplants in any large geographic area would occur on weekends or, though unlikely, that the proportion of total kidneys transplanted during that time period equaled the proportion of kidneys offered. Considerable geographic variation was noted in the proportion of transplants that occurred over the weekend (Figure 2). The Southeast (e.g., Arkansas, Alabama, South Carolina, Kentucky, West Virginia, Virginia) and Midwest (e.g., Minnesota, Iowa, Ohio) regions performed a greater than expected share of their deceased donor renal transplants on weekends. States located within the Rocky Mountains (e.g., Wyoming, Utah, Colorado, and Nevada) and Southeast regions (e.g., Arizona and Oklahoma) performed the smallest share of their transplants on the weekend (28.58%–33.51% vs. 18.98%–25.55%).

Due to the broad study period, covering 2000 to 2013, we also analyzed both the percentage of kidneys discarded and the odds of discard over 3 contiguous time periods (2000–2004, 2005–2009, and 2010–2013) (Supplementary Figure S2). Additionally, we examined whether the probability of discard by day of the week was observed across time (Supplementary Figure S3). Both subanalyses confirmed that the observed phenomena were not limited to only a part of the study period. Recent studies have also suggested that kidney discard is on the rise, following the introduction of the new kidney allocation system in the United States in 2014.[16]

A sensitivity analysis was performed to understand the impact of adjusting our logistic regression models, shown in Tables 2 and 3, for the 10 individual components of the KDPI measure (e.g., donor age, weight, height, serum creatinine) instead of the KDPI summary measure. The coefficient estimate for the primary exposure (day of the week) and