Optimal Timing of Hemodialysis Before Surgery
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**The 7-day week,** with Sunday as a day of rest, dates back to the Roman Emperor Constantine. For patients with end-stage kidney disease (ESKD) who undergo hemodialysis on a Monday, Wednesday, and Friday schedule, Sunday represents an important respite. Hemodialysis is arduous, and fatigue often persists the day after. Two days after hemodialysis, patients feel better but are due for another session. Many patients undergoing hemodialysis report that Sunday is the only day that they both feel well and do not require hemodialysis. For patients with ESKD who undergo hemodialysis on a Tuesday, Thursday, and Saturday schedule, Monday is their day of rest.

However, hemodialysis-free weekend days are associated with increased fluid and electrolyte retention that likely increase the risk of cardiac death. An analysis of United States Renal Data System data revealed that 20.2% of cardiac deaths (vs 14.3% expected, \( P = .0005 \)) occurred on Monday for patients undergoing hemodialysis on a Monday, Wednesday, and Friday schedule. Similar findings regarding the rates of cardiac death were observed on Tuesdays for patients undergoing hemodialysis on a Tuesday, Thursday, and Saturday schedule. This observation has been confirmed multiple times.

A single-center, retrospective study of sudden death in 78 patients undergoing hemodialysis showed that the risk of sudden death varied, defined by 12-hour intervals beginning with the initiation of the most recent hemodialysis session (\( P < .001 \)). Compared with an expected even distribution of deaths across all periods, deaths were unevenly distributed. The proportion of deaths was higher during the first 12-hour period after the most recent hemodialysis session (37% vs 21% expected), lowest between 12 hours and 60 hours after hemodialysis (30% vs 64%), higher at the start of the weekend interval between 60 hours and 72 hours after hemodialysis (12% vs 7%), and highest at the end of the weekend interval between 72 hours and 84 hours after hemodialysis (21% vs 7%).

Therefore, it seems reasonable that events that alter the hemodialysis schedule (such as surgery) might also alter the risk of death. In this issue of *JAMA,* Dr Fielding-Singh and colleagues performed a retrospective cohort study of 1147,846 surgical procedures in 346,828 Medicare beneficiaries, examining the relationship between the interval from hemodialysis to surgery and subsequent 90-day mortality. Many of the surgical procedures were minor and associated with a low risk of mortality. Of the 1147,846 surgical procedures, 19.6% were intraocular drug injections and fluid removal, and 10.7% were lens and cataract procedures. Nineteen percent of surgeries were related to hemodialysis access, 12.7% were vascular procedures that did not include the head or neck, and 8.6% were debridement of wound, infection, or burn.

In this study, the authors found an association between increasing time from the last hemodialysis session to surgery and subsequent rates of 90-day mortality. The day after routinely scheduled hemodialysis is the time of lowest cardiac risk, and surgery on this day would not change the hemodialysis schedule. These patients had the best outcomes vs the patients who underwent hemodialysis 2 days or 3 days before surgery and who did not undergo dialysis on the day of surgery. A 2-day interval between hemodialysis and surgery occurred in 24.9% of the procedures; these patients had surgery on the day hemodialysis normally would have occurred. It is at 48 hours after the last hemodialysis session that cardiac mortality may begin to increase, and findings in this study were consistent with this association. After adjusting for confounders, a 2-day interval between hemodialysis and surgery without same-day hemodialysis was associated with significantly increased 90-day postoperative mortality vs a 1-day interval (absolute risk [AR], 4.7% vs 4.2%; absolute risk difference [ARD], 0.6% [95% CI, 0.4% to 0.8%]; adjusted hazard ratio [HR], 1.14 [95% CI, 1.10 to 1.18]). A 3-day interval between hemodialysis and surgery with same-day hemodialysis was not associated with significantly increased 90-day postoperative mortality vs a 1-day interval (AR, 3.8% vs 4.4%; ARD, −0.6% [95% CI, −1.3% to 0.1%]; adjusted HR, 1.01 [95% CI, 0.97 to 1.05]). Thus, patients who maintained their normal hemodialysis schedule—either with surgery the day after the hemodialysis session or with surgery and hemodialysis 2 days after the last hemodialysis session—did not have an increase in 90-day mortality.

Of 346,828 patients, 9.7% had surgery 3 days after hemodialysis. For patients who underwent hemodialysis on a Monday, Wednesday, and Friday schedule, this included patients who underwent hemodialysis on Friday and surgery on Monday. For patients who underwent hemodialysis on a Tuesday, Thursday, and Saturday schedule, this included patients who underwent hemodialysis on Saturday and surgery on Tuesday. These patients were at or beyond the 60- to 72-hour period after hemodialysis that is associated with increased cardiovascular risk. Patients with a 3-day interval between hemodialysis and surgery without same-day hemodialysis had the highest 90-day mortality vs a 1-day interval (AR, 5.6% vs 4.4%; ARD, 1.2% [95% CI, 0.9% to 1.5%]; adjusted HR, 1.28 [95% CI, 1.21 to 1.35]). A 3-day interval between hemodialysis and surgery with same-day hemodialysis was associated with an increased adjusted HR of 1.07 (95% CI, 1.01 to 1.12) but not an increased AR (4.0% vs 4.4% for the 1-day interval; ARD, −0.4% [95% CI, −1.2% to 0.4%]). The investigators also found a similarly increased relative risk of 14-day and 30-day mortality with increasing preoperative hemo-

[100% confidence interval](https://jamanetwork.com/ on 11/05/2022)
dialysis-free duration, suggesting that the associations of hemodialysis timing with mortality were present early after surgery, as expected. The finding of an increased risk of cardiac death with a longer preoperative hemodialysis-free interval was also consistent with expectations.

Given that most surgeries were associated with very low mortality, a significant proportion of the mortality may have been due to changes in the patient’s hemodialysis schedule that increased the length of time from the prior hemodialysis session. However, surgery introduces cardiovascular stresses that could affect cardiac function and lead to increased mortality in patients treated with hemodialysis. In a retrospective cohort study of 36,222 patients who underwent elective major vascular surgery from 2005 to 2008, the patients who were receiving dialysis prior to surgery had a 30-day complication rate of 16.5% vs 8.4% in patients who were not receiving dialysis prior to surgery ($P < .001$). Hyperkalemia, an important risk factor for cardiac death in patients treated with hemodialysis, occurs more commonly with a longer hemodialysis-free interval and is exacerbated by fasting prior to surgery. In a study of elective parathyroidectomy in 251 patients treated with hemodialysis, perioperative hyperkalemia (serum potassium level $>5.5$ mEq/L) occurred in 53% of patients. The stress of surgery combined with the increased hemodialysis-free interval may increase surgical mortality.

There were several study limitations. First, the authors could not determine if hemodialysis on the day of surgery occurred before or after the procedure. Second, there may have been unmeasured confounding for patients who underwent surgery 3 days after their prior hemodialysis session. Patients who underwent surgery after a 3-day hemodialysis-free interval may have had less control over their schedule due to disability or other factors. For example, patients treated with hemodialysis living in nursing homes often are placed on a Monday, Wednesday, and Friday schedule because transportation is provided only on weekdays. These patients may have had surgery on Monday out of necessity. This may explain the increased 90-day mortality risk for the 3-day interval in patients undergoing hemodialysis on a Monday, Wednesday, and Friday schedule vs patients undergoing hemodialysis on a Tuesday, Thursday, and Saturday schedule. The secondary analysis that showed a high relative risk for 90-day mortality due to withdrawal of care in patients after the 2-day or 3-day interval vs the 1-day interval suggested that sicker patients may have been less able to schedule surgery in a timely fashion, possibly related to their dependence on others for care and transportation. Some surgeries may have been necessary after a 3-day interval. In particular, a patient who presented to hemodialysis after a hemodialysis-free weekend with a clotted fistula or nonfunctioning catheter would require a surgical procedure in order for hemodialysis to be performed.

Should this study change clinical practice? The study was retrospective, the increased ARs and relative risks were low, and the results were attenuated with multivariate adjustment. Therefore, this study alone is not sufficient to implement changes in hemodialysis scheduling and surgical procedures. The results suggested that surgery the day after hemodialysis might be associated with better patient outcomes, but 65.4% of surgeries were already performed on the day after hemodialysis. Scheduling surgeries the day after hemodialysis will result in less disruption of the patient’s hemodialysis schedule. Because patients typically have a standard appointment time for hemodialysis, they often have the same nurses access their fistula, and the nurses are familiar with patient-specific characteristics (e.g., changes in blood pressure with fluid removal). Patients will be familiar with their hemodialysis chair and the other patients also being treated. This consistency is beneficial to the patient and hemodialysis staff alike, and maintaining it is likely beneficial psychologically as well as from a care perspective.

In summary, Dr Fielding-Singh and colleagues provided some evidence that surgeries performed the day after hemodialysis or on the day of hemodialysis may be associated with better outcomes. Performing surgeries on the day after a hemodialysis session causes less disruption in patient care and is likely to be beneficial to patients overall.