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Original article

Trends of acute kidney injury after radical or partial nephrectomy for renal cell carcinoma

Marianne Schmid, M.D.[a,b,*,1], Nandita Krishna[a,1], Praful Ravi, M.D.[c], Christian P. Meyer, M.D.[a,b], Andreas Becker, M.D.[b], Deepansh Dalela, M.D.[d], Akshay Sood, M.D.[d], Felix K.-H. Chun, M.D.[b], Adam S. Kibel, M.D.[a], Mani Menon, M.D.[d], Margit Fisch, M.D.[b], Quoc-Dien Trinh, M.D.[a], Maxine Sun, B.Sc.[a]

[a] *Division of Urologic Surgery, Center for Surgery and Public Health, Harvard Medical School, Brigham and Women's Hospital, Boston, MA*
[b] *Department of Urology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany*
[c] *Department of Medicine, Mayo Clinic, Rochester, MN*
[d] *Center for Outcomes Research, Analytics, and Evaluation, Vattikuti Urology Institute, Henry Ford Health System, Detroit, MI*

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Abstract

Objectives: To investigate the prevalence, temporal trends, and predictors of postoperative acute kidney injury (AKI) in a large cohort of patients with renal cell carcinoma treated with radical or partial nephrectomy.

Methods: Between January 1998 and December 2010, patients who underwent radical or partial tumor nephrectomy were identified within the Nationwide Inpatient Sample. First, prevalence and temporal trends of AKI were analyzed. Second, predictors of AKI were identified using multivariable regression analyses. Third, associations between AKI and in-hospital complications, length of stay, hospital costs, and in-hospital mortality were evaluated using logistic regression models adjusted for clustering.

Results: Of total 253,046 patients, 5.5% (14,303 in radical and 3,525 in partial nephrectomy) experienced AKI. Rates of AKI significantly increased from 2.0% in 1998 to 10.4% in 2010 ($P < 0.001$). Predictors of AKI included male sex, radical nephrectomy, more contemporary years (2004–2010), older age, black race, higher comorbidities, higher preoperative chronic kidney disease stage, Medicare insurance status, and nephrectomy at urban hospitals (all $P < 0.01$). Postoperative AKI during hospitalization was associated with an increased rate of in-hospital mortality, any complications, transfusion, prolonged length of stay, and higher hospital costs (all $P < 0.001$).

Conclusions: Rising rates of in-hospital AKI after radical and partial nephrectomy were observed. Increasing awareness of AKI, identification of patients at risk before surgery, early postoperative AKI diagnosis, collaboration with nephrologists, implementation of renoprotective strategies, long-term renal functional follow-up, and a well-designed prospective study, may be warranted.

Keywords: Radical nephrectomy; Partial nephrectomy; Renal cell carcinoma; Acute kidney injury; Trends; Nationwide inpatient sample

1. Introduction

With the growing incidence of urologic cancers, there would be an increasing demand on urologic health care and surgery in the coming decades [1]. Specifically, renal cell carcinoma (RCC) is among the most common cancers in both men and women. In 2014, an estimated 63,920 new cases were diagnosed in the United States. Incidence of RCC continues to rise in recent years, where the majority is of localized nature [2]. The gold standard treatment for clinically

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[1]These authors equally contributed for this work.

[*] Corresponding author. Tel.: +1-617-732-6325; mobile: +1-857-210-7801; fax: +1-617-566-3475.

E-mail address: dr.marianne.schmid@gmail.com (M. Schmid).

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localized RCC is surgical excision via radical nephrectomy (RN) or partial nephrectomy (PN), both of which provide comparable cancer control [3]. However, nephrectomy still remains a risk factor for worse renal function after surgery [4].

New consensus criteria as well as increasing reports of incidence and adverse effects on long-term renal function and mortality have fueled the awareness of postoperative acute kidney injury (AKI) following RN or PN [5–9]. In general, AKI is associated with higher odds of postoperative complications, prolonged hospital stay, higher mortality, and greater costs [10]. An AKI following RN is likely related to the proportion of removed renal parenchyma, whereas AKI after PN may be associated with ischemia and hyperfiltration of remaining tissue or both [11,12]. Data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) revealed an AKI rate of 1.8% in 3,300 patients undergoing RN or PN [13]. The NSQIP analysis included patients treated from 2005 to 2011 only. Hence, long-term trends on AKI in patients with RCC are not available. In addition, the NSQIP initially included mostly private sector and high-volume academic hospitals and only in 2011 did they start including smaller and rural hospitals.

On the basis of these considerations, our primary objective was to examine the prevalence, temporal trends, and predictors of postoperative AKI in patients with RCC treated with RN or PN by relying on a large, contemporary, population-based cohort representative of the entire U.S. population. In exploratory analyses, we examined the associations of in-hospital AKI with postoperative complications, prolonged length of stay (pLOS), hospital costs, and in-hospital mortality.

2. Materials and methods

2.1. Data source

The Nationwide Inpatient Sample (NIS) is a set of hospital inpatient databases included in the Healthcare Cost and Utilization Project family and is maintained by the Agency for Healthcare Research and Quality through a federal-state partnership. The NIS represents the largest publicly available U.S. database with charge information on all patients regardless of payer, including persons covered by Medicare, Medicaid, Private insurance, and the uninsured. The NIS captures approximately a fifth of all hospital admissions in the United States and contains data from more than 7 million hospital stays each year. Weighted, the NIS estimates more than 36 million hospitalizations nationwide [14]. All procedures and diagnoses captured within the NIS are coded using the International Classification of Disease, Ninth revision, Clinical Modification (ICD-9-CM).

2.2. Study population

Inpatient data of 77,664 patients were extracted from the NIS between January 1, 1998 and December 31, 2010, based on ICD-9-CM diagnosis codes for kidney cancer (189.0) and concomitant procedure codes for RN (55.5 and 55.51) and PN (55.4). We excluded patients younger than 18 years ($n = 1{,}388$), patients with metastatic disease ($n = 64{,}814$), patients with diagnosis of end-stage renal disease (ESRD) requiring dialysis ($n = 845$), as well as discharges with codes associated with dialysis but without AKI diagnosis ($n = 895$), as in previously reported methodology [15]. Sampling weights were applied to provide national estimates of the examined cohort. This resulted in a total of 324,222 weighted patients with nonmetastatic RCC not on dialysis before RN or PN who were eligible for analysis.

2.3. Patient and hospital characteristics

Patient characteristics included age at surgery (<60, 60–69, 70–79 and 80+ y), race (White, Black, other, or unknown), insurance status (Medicare, Medicaid, Private, and uninsured), median household income according to ZIP Code of residence (very low: 1–24.999 USD, low: 25.000–34.999 USD, high: 35.000–44.999 USD, and very high: >45.000 USD), Charlson comorbidity index (CCI: 0, 1, 2, and >3), adapted according to Deyo et al. [16], and year of surgery (1998–2003 and 2004–2010). We also examined specific comorbidities such as obesity, diabetes, hypertension, cardiovascular disease, anemia, and chronic kidney disease (CKD) stage (no CKD/stage I–II: 585.1, 585.2, stage III–V/ESRD without dialysis: 585.3, 585.4, 585.9, and unspecified). Furthermore, we captured surgical approach (open and minimally invasive). Hospital characteristics included hospital location (rural and urban), which were obtained from the American Hospital Association Annual Survey of Hospitals and defined by the United States Census [17], as well as volume and teaching status. Hospital volume was defined as the annual hospital caseload, namely the annual discharge volume per hospital divided by the number of years. Subsequently, hospital volume representing the annual hospital caseload was classified into 4 equal quartiles (very low: 1–10, low: 11–21, high: 22–39, and very high: >40) [18].

2.4. End points

The primary end point was AKI without hemodialysis. As a secondary end point, we also examined the occurrence of AKI requiring hemodialysis. Occurrence and trends were evaluated using ICD-9 diagnostic codes (AKI: 584.x; patients with ESRD requiring chronic dialysis or discharges with dialysis-associated codes: 585.6, 39.95, V45.1, V56.0, C56.1, 54.98, 39.27, 39.42, 39.43, 39.93, and 792.5) [19]. Other examined end points consisted of in-hospital mortality; postoperative complications (intraoperative, cardiac, respiratory, vascular, wound, genitourinary, gastrointestinal, neurological, infection, and miscellaneous complications);