ORIGINAL RESEARCH

Reporting of Estimated Glomerular Filtration Rate: Effect on Physician Recognition of Chronic Kidney Disease and Prescribing Practices for Elderly Hospitalized Patients

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BACKGROUND: Physician recognition of chronic kidney disease (CKD) in elderly patients has been noted to be poor. These patients are at increased risk of medication dosing errors and acute renal failure.

OBJECTIVE: To investigate the effect of reporting estimated glomerular filtration rate (GFR) of elderly hospitalized patients on physician recognition of CKD and physician prescribing behaviors.

DESIGN: A retrospective combined with a prospective medical record review project.

SETTING: A large academic medical center.

PATIENTS: Patients included were 65 years of age or older and had creatinine values within the normal laboratory range (< 1.6 mg/dL).

INTERVENTION: Reporting a calculated estimate of GFR to physicians.

MEASUREMENTS: Rates of recognition of CKD were examined before and after the intervention. The effects of the intervention on prescription of renal-dosed antibiotics and nonsteroidal anti-inflammatory drugs (NSAIDS) and cyclooxygenase- 2 inhibitors (COX-2) at hospital discharge were assessed.

RESULTS: A total of 260 and 198 patients were included before and after the intervention, respectively. Recognition of chronic kidney disease was low in both groups but demonstrated a significant increase following reporting of estimated GFR (3.9% to 12.6%, $P < .001$). Reporting of GFR was not associated with a significant decrease in prescription of NSAID/COX-2 medications or increased rates of correct dosing of antibiotics ($P = .10$ and $P = .81$, respectively).

CONCLUSIONS: Although reporting of estimated GFR was associated with improved physician recognition of CKD in elderly hospitalized patients, it did not lead to a change in physician prescribing. More extensive interventions are necessary to increase recognition and decrease medication dosing errors. *Journal of Hospital Medicine* **2007;2:74–78.** © *2007 Society of Hospital Medicine.*

KEYWORDS: medical errors, geriatric patient, drug safety, chronic renal failure.

Chronic kidney disease is increasingly recognized as a significant public health issue, especially as our population ages. In the United States, it is estimated that 19.2 million individuals have chronic kidney disease (CKD), with an increasing prevalence in the elderly.[1] CKD is associated with a higher mortality rate, as well as an increased risk of having several comorbidities, including anemia, coronary artery disease, and congestive heart failure.[2–4] Early recognition, intervention, and management of patients with CKD by physicians has been shown to slow progression of disease

and decrease complications.[5–7] In the hospital setting, patients with CKD are at increased risk of medication dosing errors and acute renal failure (ARF).[8–10]

Serum creatinine is the most commonly used laboratory marker for assessing renal function. However, creatinine level is an imprecise measure of overall renal function, especially in older patients. The most recent National Kidney Foundation/ Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines recommend laboratory reporting of a calculated estimate of GFR.[11] Equations used to calculate estimated GFR in adults, including the Cockcroft-Gault (C-G) equation, have been shown to provide an estimate of renal function, which can be used to clinically stratify varying levels of impaired renal function.[11] Several studies have demonstrated that recognition of CKD by physicians is low in various clinical settings, especially in elderly patients.[12–15] Compliance with renal-dose medication guidelines has also frequently been noted to be poor.[16, 17]

The investigators conducted a chart review study before and after reporting of estimated GFR to physicians in a hospital setting to assess the effect on physician recognition of CKD, the primary outcome. Secondary outcomes included the effect of reporting GFR on physician prescribing behaviors at the time of hospital discharge, including dosing of renal-dosed antibiotics and use of nonsteroidal anti-inflammatory (NSAID) and cyclooxygenase type 2 inhibitor (COX-2) medications.

METHODS

This study was a retrospective chart review, with a prospective chart review as a comparison. Patients selected were admitted to a general medical floor in a 900-bed academic medical center over the 2 years from 2002 to 2004. Computerized databases of laboratory values and weights obtained during hospitalization were used to select patients who fulfilled the following criteria: age > 65 years, all creatinine values during hospitalization < 1.6 mg/dL, and calculated estimated creatinine clearance (CrCl) < 60 mL/min using the Cockcroft-Gault (C-G) formula. The C-G equation was developed for estimating CrCl and has also been extensively tested as a predictor of GFR. K/DOQI guidelines identify the C-G equation as the most frequently used equation to estimate GFR in adults.[11] To ensure steady-state renal function, patients were excluded if creatinine varied by more than 0.4 mg/dL during their hospi-

talization. Based on an anticipated CKD recognition rate of 24%,[13] our study sample size was selected to detect a 13% difference in the primary end point between the pre- and postintervention groups with 80% power. The study was approved by the institutional review board of the medical school.

Patient charts were reviewed with data obtained from the medical record, including physician notes, discharge summaries, orders, medication lists, and discharge prescriptions. Physician recognition was defined by documentation of CKD, calculated CrCl, or GFR in the physician notes or discharge summary. Charts were reviewed for diagnosis of hypertension (HTN) or diabetes (DM), and discharge medications including NSAID and COX-2 medications and use and correct dosing of antibiotics requiring dose adjustment in patients with decreased GFR. Aspirin was not included as an NSAID.

For the prospective chart review portion, patients were selected at the time of admission on the basis of the same criteria. A notification was placed in the chart prominently listing the patient's estimated GFR calculated using the C-G equation. Also included was a list of the stages of chronic renal disease based on the most recent K/DOQI guidelines[11] and recommendations on dosing of select renal-dosed antibiotics. Patients were again excluded if creatinine varied more than 0.4 mg/dL during their hospitalization.

Data Analysis

For statistical analysis, the association between recognition of CKD and the chart intervention, unadjusted for covariates, was evaluated using a contingency table. Additionally, the associations between recognition of CKD and other patient covariates—sex, diabetes, hypertension, estimated GFR—were analyzed both individually and jointly. For individual covariate analysis, Fisher's exact test was used in all tests for association. For joint analysis, a set of relevant covariates was determined by stepwise logistic regression. The association of CKD recognition and the intervention was again analyzed using logistic regression while adjusting for this set of relevant covariates.

Finally, an analysis of appropriate medication prescribing at the time of hospital discharge was carried out to assess the effect of reporting estimated GFR. Prescription of NSAID or COX-2 medications and correct dosing of renal-dosed antibi-

TABLE 1
Patient Characteristics and Results in Pre- and Postintervention Groups

Characteristics	Preintervention	Postintervention
Total number	260	198
Age (years)	81.1 ± 6.6	82 ± 6.8
Sex (female)	199 (76.5)	168 (84.8)
Serum creatinine (mg/dL)	0.98 ± 0.2	0.9 ± 0.2
C-G CrCl (mL/min)	41.5 ± 10.2	41.4 ± 9.3
DM	58 (22.3)	63 (31.8)
HTN	190 (73.1)	152 (76.7)
Physician recognition of CKD	10 (3.9)	25 (12.6)
NSAID or COX-2 prescribed at discharge	35 (13.5)	21 (10.6)
Antibiotic requiring renal-dose adjustment prescribed at discharge	50 (19.2)	29 (14.2)
Correct dosing of renal-dosed antibiotic at discharge*	28 (56.0)	18 (62.1)

Abbreviations: C-G, Cockcroft-Gault equation; CrCl, creatinine clearance; DM, diabetes; HTN, hypertension; NSAID, nonsteroidal anti-inflammatory medication; COX-2, cyclooxygenase-2 inhibitor; CKD, chronic kidney disease.

All data presented as number (%) or mean ± standard deviation.

CrCl used as a predictor of estimated glomerular filtration rate (GFR).

*Numbers in parentheses indicate percentage of the subset of patients discharged on renal-dosed antibiotic.

otics at discharge were analyzed separately. As in the exploratory covariate analysis, Fisher's exact test for association was used.

RESULTS

Study Population

Characteristics of the study cohort are summarized in Table 1. The pre- and postintervention groups had 260 and 198 patients, respectively. Most were female. Average age, serum creatinine, and estimated GFR were similar in both groups.

Effect of Intervention on Recognition of CKD

Table 1 shows the number of patients recognized by physicians as having CKD in both groups. Prior to the study intervention, CKD was recognized in only 10 of 260 patients (3.9%), and following the intervention, rates increased to 25 of 198 patients (12.6%; $P \leq .001$).

The results of the stepwise logistic regression of the covariates on CKD recognition showed that CKD recognition was modeled best with diabetes and lower estimated GFR. This corresponded well with the results of the individual covariate analyses. Thus, the primary outcome was again modeled by the intervention and the covariates diabetes and lower estimated GFR. With the addition of the covariates, the intervention was still a significant predictor of CKD recognition ($P = .001$), with an odds ratio of 4.07 (95% CI = (1.83,9.01)).

Effect of Intervention on Medication Prescribed at Hospital Discharge

Table 1 shows the number of patients discharged on NSAID/COX-2 medications and renal-dosed antibiotics in both the pre- and postintervention groups. Physicians prescribed NSAID/COX-2 medications in 13.5% of patients preintervention and in 10.6% postintervention ($P = .10$). Overall, 12% of patients were discharged on a NSAID/COX-2 medication. Reporting of estimated GFR did not have a significant effect on correct dosing of antibiotics at discharge ($P = .81$). Overall, 40% of renal-dosed antibiotics were dosed incorrectly at the time of discharge.

DISCUSSION

This study has confirmed the findings of other investigators that significant CKD is underdiagnosed by physicians, especially in elderly patients with creatinine values within the normal laboratory range.[13,14] Investigators have demonstrated improved documentation of CKD with reporting of creatinine clearance and other simple educational interventions in an outpatient setting.[13] In this study, reporting of estimated GFR did result in a significantly higher rate of recognition, but the overall rate was still very low in both groups (3.9%-12.6%).

Although physician recognition of CKD did increase with the reporting of estimated GFR, this study found no significant impact on prescribing

behaviors. Previous studies have shown an association between documentation of specific diagnoses and appropriate physician management.[15,18] However, the current data suggest that simply reporting GFR and increasing physician recognition of CKD may not lead to a significant decrease in medication dosing errors and that more extensive educational measures may be required.

Hospitalist physicians are increasingly serving as the primary caregivers for an aging population of hospitalized patients, and it is imperative that physicians recognize decreased GFR in elderly patients. Clearly, medication dosing errors are occurring in these patients, increasing the risk of adverse drug reactions.[19] Elderly patients with renal impairment are also at increased risk of ARF while hospitalized.[9,10] Recognition of CKD by inpatient physicians identifies those patients who require preventive measures including maintenance of adequate hydration and avoidance of hypotension and nephrotoxic agents. Prevention of ARF in these patients has important clinical implications, as the mortality of patients is higher for elderly patients who develop hospital-acquired ARF than for those presenting with community-acquired ARF.[20] Development of ARF has also been shown to increase length of hospitalization.[21] Hospitalist physicians can also use the period of hospitalization as an opportunity to identify patients at risk of progressive CKD and in need of close follow-up and possible referral to a nephrologist.

This study had several limitations. It was performed at a single institution, and therefore results may not be generalizable to all medical centers. The primary outcome of CKD documentation is an imperfect measure of recognition. The fact that chart documentation of CKD increased following the intervention suggests that documentation is associated with recognition, although it may be an underestimate. The effects of reporting estimated GFR on other secondary outcomes, including dosing of other medications, prevention of ARF, and length of hospital stay were not examined and deserve further investigation. The C-G equation was chosen to calculate estimated GFR. There may be some advantage to using the Modification of Diet in Renal Disease equation as an alternative, but it is unclear if this is true in elderly female patients, who made up most of our study population.[22–25] Although using a prediction equation is clearly superior to using creatinine measurement solely to assess renal function in patients, further study is needed to identify the most accurate and effective formula for calculating estimated GFR in elderly patients.

The low rate of recognition of CKD by physicians found in this and other studies demonstrates the strong need for improvement in this area. Low recognition of CKD and a high rate of medication dosing errors despite reporting of the estimated GFR suggest that simply reporting GFR in addition to creatinine level is not sufficient. Further research is indicated to identify pragmatic educational tools and feedback mechanisms that effectively improve inpatient physician recognition of CKD and decrease medication dosing errors in elderly hospitalized patients.

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