Nephrol Dial Transplant (2011) 26: 360–364
doi: 10.1093/ndt/gfq618
Advance Access publication 4 October 2010

Preliminary Communication

NDT
Nephrology Dialysis Transplantation

Chronic kidney disease and 1-year survival in elderly patients discharged from acute care hospitals: a comparison of three glomerular filtration rate equations

Andrea Corsonello[1], Claudio Pedone[2,3], Fabrizia Lattanzio[4], Antonio Cherubini[5], Graziano Onder[6], Francesco Corica[7], Luigi Pranno[8], Vincenzo Mari[9], Irma Laino[1], Sabrina Garasto[1], Raffaele Antonelli Incalzi[2,10] and on behalf of the PharmacosurVeillance in the elderly Care (PVC) study group

[1]Unit of Geriatric Pharmacoepidemiology, Italian National Research Centres on Aging (INRCA), Cosenza, Italy, [2]Chair of Geriatrics, University Campus BioMedico, Rome, Italy, [3]Fondazione Alberto Sordi, Rome, Italy, [4]Scientific Direction, Italian National Research Centres on Aging (INRCA), Ancona, Italy, [5]Institute of Gerontology and Geriatrics, Department of Clinical and Experimental Medicine, University of Perugia, Perugia, Italy, [6]Department of Gerontology, Geriatrics and Physiatry, Catholic University of Sacred Heart, Rome, Italy, [7]Department of Internal Medicine, University of Messina, Italy, [8]Unit of Geriatric Medicine, Italian National Research Centres on Aging (INRCA), Cosenza, Italy, [9]Unit of Clinical Pathology, Italian National Research Centres on Aging (INRCA), Cosenza, Italy and [10]San Raffaele Foundation, Cittadella della Carità, Taranto, Italy

Correspondence and offprint requests to: Andrea Corsonello; E-mail: andrea_corsonello@tin.it

Abstract

Background. Glomerular filtration rate (GFR) is directly associated with survival. However, the prognostic significance of GFR might be different according to the formula used to estimate it. We aimed at comparing the association between GFR estimated using three different formulas and 1-year survival in elderly patients discharged from acute care hospitals.

Methods. Our series consisted of 439 patients aged 65 and older admitted to 11 acute care medical wards enrolled in a multicentre prospective observational study. GFR was estimated by body surface area-adjusted Cockcroft–Gault (CG-BSA), Modification of Diet in Renal Disease study (MDRD) and Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formulas. The relative risk of mortality in patients with estimated GFR = 30–59.9 or <30 mL/min/1.73 m^2 compared to people with estimated GFR ≥60 mL/min/1.73 m^2 was calculated using Cox regression analysis.

Results. Participants with reduced GFR showed an increased mortality, regardless of the equation used, and the highest one was associated with CG-BSA-estimated GFR <30 mL/min/1.73 m^2. After adjusting for potential confounders, CKD-EPI-estimated GFR remained significantly associated with the outcome [30–59.9 mL/min/1.73 m^2, hazard ratio (HR) = 1.70, 95% confidence interval (95% CI) = 1.02–2.98; <30 mL/min/1.73 m^2, HR = 2.60, 95% CI = 1.20–5.66], while the strength of the association was clearly reduced for MDRD (30–59.9 mL/min/1.73 m^2, HR = 1.47, 95% CI = 0.83–2.38; <30 mL/min/1.73 m^2, HR = 2.07, 95% CI = 1.01–4.30) and CG-BSA (30–59.9 mL/min/1.73 m^2, HR = 1.79, 95% CI = 0.67–4.53; <30 mL/min/1.73 m^2, HR = 2.68, 95% CI = 0.92–7.55).

Conclusion. GFR adds to the list of prognostic indicators in elderly and frail people, and CKD-EPI-derived GFR, which outperforms to some extent MDRD and CG-BSA-derived GFR in a multivariable predictive model, seems worthy of testing in wider populations.

Keywords: elderly; glomerular filtration rate; survival

Introduction

Chronic kidney disease (CKD) is a major predictor of mortality in both the general population and the selected diseased population [1,2]. For instance, the risk of death in a broad adult population over an average follow-up period of about 3 years dramatically increased for each 15 mL decrease in glomerular filtration rate (GFR) below the threshold of 60 mL/min/m^2 [1]. In the elderly, CKD predicts mortality as well, besides being an important correlate of functional limitation [3] and adverse reactions to hydrosoluble drugs [4,5]. CKD should be promptly recognized because there is unequivocal evidence that its progression can be slowed by optimally treating conditions such as diabetes and hypertension [6]. Even severe CKD benefits from optimal treatment of underlying conditions as well as of selected pharmacological and non-pharmacological, mainly dietary protein restriction [7,8], measures. Unfortunately, serum creatinine (Scr), the most universally used marker of renal function, is poorly reliable in elderly and

disabled patients due to sarcopaenia depleting the muscle content of creatinine and thus, Scr. Furthermore, GFR, more than Scr, guarantees a set of clinically meaningful intervals [9]. Thus, formulas have been developed to estimate GFR on the basis of selected anthropometric and serum indicators. The most commonly used formula, the Modification of Diet in Renal Disease (MDRD) formula, has been repeatedly validated against the gold standards (GFR obtained through radionuclide method or iothalamate clearance) and found to lose accuracy in the upper range of GFR [10]. In an attempt to overcome this limitation, a new equation has been developed in a large adult population and has been proved to gain in accuracy with respect to the MDRD [11]. However, in the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) study, both training and testing populations were almost completely devoid of subjects over 70 years, who are those with the highest prevalence of GFR and the greatest burden of GFR-related negative outcomes [11]. In an elderly population, the performance of this formula might not be as good, and also the prognostic significance of a reduced GFR might be different according to the formula used to estimate it. Indeed, age affects differently the estimated GFR in different formulas, and weight contributes to generating GFR only in the Cockcroft–Gault (CG) formula. Given that both age and weight are primary prognostic determinants in elderly populations, these differences, and not only the accuracy of GFR estimation, likely affect the prognostic meaning of individual formulas. Indeed, in a home-dwelling elderly population CG, but not MDRD, could predict 6-year mortality [12]. Accordingly, we hypothesized that the three formulas (CG, MDRD and CKD-EPI) are differently related to survival and tested this hypothesis with respect to 1-year survival in an elderly population discharged from acute care medical wards.

Materials and methods

We used data from a collaborative observational study group, the PharmacosurVeillance in the elderly Care—PVC, based in community and university hospitals located throughout Italy, aimed at surveying drug consumption, occurrence of adverse drug reactions and quality of hospital care [13,14]. The methods of the PVC study were extensively described previously [13,14]. Briefly, data collection included demographics, socioeconomic and clinical data, detailed information on pharmacological therapy and comprehensive geriatric assessment covering the following domains: cognitive (Mini-Mental State Examination) [15], mood (Geriatric Depression Scale) [16], disability (Basic Activities of Daily Living, BADL) [17,18] and comorbidity (Cumulative Illness Rating Scale, CIRS) [19]. Once discharged, patients were followed up every 3 months for 1 year.

Overall, 690 patients were enrolled in the survey period. Twenty-five patients who died during hospital stay were excluded from the analysis, as were patients having missing values for any of the variables used to calculate estimated GFR (n = 67). In order to avoid heterogeneity of data, patients enrolled in long-term care/rehabilitation units (n = 159) were also excluded from the analysis, leaving a final sample of 439 patients for the analysis. All of them were successfully tracked during the follow-up period.

GFR estimation

Scr was measured by standardized Jaffé method in all laboratories of participating centres. GFR was estimated using the following formulas: CG [20], MDRD [21] and CKD-EPI [11].

Since the MDRD and CKD-EPI formulas are corrected for body surface area (BSA), while CG formula is not, we resolved to adjust CG-estimated value for BSA calculated by the Mosteller's formula [22] in order to minimize discrepancies between the three different methods.

Analytic approach

First, we compared death and survival of patients with regard to factors known to affect the prognosis in frail populations: age, gender, cognitive impairment, physical impairment (dependency in activities of daily living, being disabled at physical performance items) and overall comorbidity. Afterward, we investigated the ability of CKD-EPI, MDRD and CG-BSA formulas to predict 1-year survival in the hospital study population. Kaplan–Meier survival curves with the Mantel–Cox log-rank and Breslow tests were used to compare crude survival of patients with different degrees of renal dysfunction. The time from hospital discharge to the day of death was used as the time to failure variable for the model. Survivors were censored on the day of the last follow-up visit. Unadjusted death rate and 95% confidence intervals (95% CI) in patients grouped on the basis of their renal function were calculated. Finally, to obtain a deconfounded estimate of the relative risk of mortality in patients with estimated GFR = 30–59.9 or <30 mL/min/1.73 m^2 compared to people with estimated GFR ≥60 mL/min/1.73 m^2, we used Cox regression models. The proportional hazard assumption was tested graphically, plotting the log-minus-log survival function over time. The model was adjusted for variables significantly distinguishing groups in univariable analysis. Since nutritional status may affect the GFR estimation, as well as the relationship between estimated GFR and survival, we also investigated the impact of selected nutritional variables (BMI and hypoalbuminaemia, defined as serum albumin <3.5 g/dL) eventually distinguishing groups on adjusted hazard ratio (HR) estimates.

Results

Overall, 58 patients died over a cumulative follow-up time of 4399 months, with an estimated incidence rate of 15.8/100 person-year (PY) (95% CI: 11.7–20.0). Patients who died during the follow-up period were older, had a greater prevalence of cognitive and physical impairment and had a greater burden of cumulative comorbidity. Mean CKD-EPI-estimated GFR values in patients who died and those who survived were 47.9 (SD: 20.3) and 58.5 (SD: 20.3) mL/min/1.73 m^2 ($P < 0.001$), respectively. The corresponding figures for MDRD- and CG-BSA-estimated GFR were 51.9 (SD: 23.1) and 62.9 (SD: 23.4) mL/min/1.73 m^2 ($P < 0.001$), and 39.5 (SD: 20.3) and 49.6 (SD: 20.3) mL/min/1.73 m^2 ($P < 0.001$), respectively. Reduced GFR was significantly associated with death in univariable analysis. However, GFR <60 mL/min/1.73 m^2 was associated with mortality when GFR was estimated by CKD-EPI or MDRD equations, but not with CG-BSA equation (Table 1).

Unadjusted analysis showed that survival was significantly reduced in groups with reduced GFR estimates regardless of the formula used. However, CG-BSA- and CKD-EPI-based categories of renal function had the strongest association with 1-year survival. Indeed, crude death rate rose from 9.3/100 PY (95% CI = 1.9–13.7) for patients with CKD-EPI >60 mL/min/1.73 m^2 to 18.9/100 PY (95% CI = 12.1–25.7) and 39.7/100 PY (95% CI = 17.5–61.9) for patients with CKD-EPI 30–59.9 and <30 mL/min/1.73 m^2, respectively (log-rank = 14.7, $P < 0.001$; Breslow = 17.2, $P < 0.001$). The corresponding figures obtained with MDRD were 11.2/100 PY (95% CI = 6.6–15.8), 18.8/100 PY (95% CI = 11.4–26.2) and 35.8/100 PY (95% CI = 13.9–57.7), respectively (log-rank = 9.4, P = 0.002;

Table 1. Socio-demographic and clinical characteristics of survivors (n = 381) and dead (n = 58) patients

	All n = 439	Survived n = 381	Dead n = 58	P
Age, years	79.7 ± 5.9	79.2 ± 5.7	83.0 ± 6.1	0.001
Sex, females	55.1	54.3	60.3	0.391
BMI, kg/m^2	25.2 ± 4.2	25.1 ± 4.1	25.5 ± 5.0	0.482
Hypoalbuminaemia	42.6	39.4	63.8	0.001
Dependent in at least 1 BADL	30.3	25.5	62.1	0.001
Cognitive impairment	50.3	47.0	72.4	0.001
Depressive symptoms	39.9	39.1	44.8	0.407
CIRS severity	1.8 ± 0.3	1.8 ± 0.3	1.9 ± 0.4	0.034
CIRS comorbidity	3.8 ± 1.9	3.7 ± 1.8	4.3 ± 2.0	0.038
CKD-EPI-estimated GFR, mL/min/1.73 m^2				0.001
≥60	47.6	50.4	29.3	
30–59.9	42.6	41.5	50.0	
<30	9.8	8.1	20.7	
MDRD-estimated GFR, mL/min/1.73 m^2				0.013
≥60	54.4	56.7	39.7	
30–59.9	36.7	35.7	43.1	
<30	8.9	7.6	17.2	
CG-BSA-estimated GFR, mL/min/1.73 m^2				0.001
≥60	24.8	27.0	10.3	
30–59.9	59.5	59.6	58.6	
<30	15.7	13.4	31.0	

Data are percentage or mean ± SD.

Table 2. Cox regression analysis of selected risk factors to 1-year mortality

	Crude HR (95% CI)	Adjusted HR (95% CI)
CKD-EPI-estimated GFR, mL/min/1.73 m^2		
≥60	1.0	1.0
30–59.9	2.0 (1.10–3.64)	1.70 (1.02–2.98)
<30	4.10 (1.96–8.60)	2.60 (1.20–5.66)
Age, years		1.05 (1.0–1.10)
Sex, females		1.13 (0.66–1.94)
Hypoalbuminaemia		1.83 (1.04–3.22)
Dependent in at least 1 BADL		2.30 (1.24–4.29)
Cognitive impairment		1.58 (0.85–2.94)
CIRS severity		1.95 (0.39–9.73)
CIRS comorbidity		0.97 (0.71–1.31)
MDRD-estimated GFR, mL/min/1.73 m^2		
≥60	1.0	1.0
30–59.9	1.67 (0.95–2.94)	1.47 (0.83–2.38)
<30	3.13 (1.50–6.58)	2.07 (1.01–4.30)
Age, years		1.06 (1.01–1.11)
Sex, females		1.13 (0.65–1.94)
Hypoalbuminaemia		1.78 (1.01–3.15)
Dependent in at least 1 BADL		2.30 (1.23–4.29)
Cognitive impairment		1.59 (0.85–2.96)
CIRS severity		1.93 (0.40–9.64)
CIRS comorbidity		0.98 (0.73–1.33)
CG-BSA-estimated GFR, mL/min/1.73 m^2		
≥60	1.0	1.0
30–59.9	2.59 (1.09–6.17)	1.79 (0.67–4.53)
<30	5.62 (2.23–14.2)	2.68 (0.92–7.55)
Age, years		1.04 (0.99–1.09)
Sex, females		1.19 (0.70–2.04)
Hypoalbuminaemia		1.81 (1.03–3.18)
Dependent in at least 1 BADL		2.28 (1.23–4.25)
Cognitive impairment		1.64 (0.88–3.06)
CIRS severity		2.31 (0.46–10.6)
CIRS comorbidity		0.96 (0.70–1.30)

Breslow = 11.5, P < 0.001). Crude death rates obtained with CG-BSA were 6.0/100 PY (95% CI = 1.1–10.9), 15.8/100 PY (95% CI = 10.5–21.1) and 35.2 (95% CI = 18.8–51.6), respectively (log-rank = 16.1, P < 0.001; Breslow = 19.2, P < 0.001). After adjusting for potential confounders significantly distinguishing groups in univariable analysis, CKD-EPI-estimated GFR remained significantly associated with the outcome, while the strength of the association was clearly reduced for MDRD and CG-BSA (Table 2). Interestingly, when hypoalbuminaemia was removed from the multivariable model, the strength of the association between GFR and survival remained substantially unchanged with CKD-EPI (30–59.9 mL/min/1.73 m^2: HR = 1.72, 95% CI 1.02–2.82; <30 mL/min/1.73 m^2: HR = 2.64, 95% CI 1.21–5.76) and MDRD (30–59.9 mL/min/1.73 m^2: HR = 1.57, 95% CI 0.90–2.82; <30 mL/min/1.73 m^2: HR = 2.09, 95% CI 1.06–4.65), while it was significantly improved with CG-BSA (30–59.9 mL/min/1.73 m^2: HR = 1.86, 95% CI 0.85–4.66; <30 mL/min/1.73 m^2: HR = 2.83, 95% CI 1.02–7.81).

Discussion

This study shows that reduced GFR, measured by any of the three tested predictive equations, is an important risk factor for mortality in elderly and frail people discharged from acute care medical wards. However, the CKD-EPI-based estimation of GFR achieves the best grading of the risk of death as a function of GFR categories, whereas the CG is associated with the greatest absolute risk for GFR <30 mL/min/1.73 m^2.

If mortality reflects to some extent CKD, it could be argued that the CKD-EPI-based estimation of GFR likely represents the most reliable one even in such a complex population. Nevertheless, CKD-EPI outperformed MDRD and CG-BSA formulas only to a limited extent, and the fact that GRF <30 mL/min/1.73 m^2 was associated with the greatest risk of death if computed by the CG-BSA formula seems noteworthy: it might be due to the role that weight has in the CG-BSA formula, as CG-BSA-based GFR decreases noticeably for very low weight and, to a considerable extent, reflects malnutrition. On the other hand, both CKD-EPI and MDRD lack a nutritional term in their equations, and malnutrition can falsely depress Scr, even in the presence of depressed renal function. This underlies the K-DOQI statement that in malnourished patients 'the creatinine clearance may provide better estimates of GFR than prediction equations' [9]. Accordingly, in a highly diseased and disabled population, the association between malnutrition and severe CKD might explain the distinctive prognostic role of CG-BSA. Supporting this interpretation is the finding of an important direct relation-

ship between BMI and CG-BSA-based GFR as well as that of a stronger correlation between CG-BSA-based GFR and measured creatinine clearance than between MDRD-based GFR and measured creatinine clearance in a very old and frail population [23]. Finally, body weight is strongly correlated to survival in older populations, and moderate overweight does not worsen, but rather is associated with improved survival [24]. This clearly magnifies the negative prognostic effect of being underweight and then, of low GFR measured by weight, including the CG formula.

It is of interest that the survival curve as a function of CG-BSA-based GFR had the best Breslow and log-rank coefficients, stating that both early and late survival were very reliably predicted by GFR. Only the deconfounded estimation of the GFR–survival relationship disclosed that CKD-EPI outperformed both MDRD and CG-BSA as an independent risk factor for death. In the multivariable model, the inclusion of low serum albumin, a primary nutritional index, among independent variables significantly weakened the predictivity of GFR = 30–59.9 mL/min/1.73 m^2 when computed by the CG-BSA, but not by the CKD-EPI or MDRD equation, confirming that the prognostic power of the CG-BSA largely reflects the nutritional status.

Previous evidence on the performance of CKD-EPI formula is limited to young and adult populations [25,26]. Thus, our study first shows that the CKD-EPI formula seems well suited also for the elderly and frail population, at least as it can be inferred from its prognostic role. This finding is clinically and epidemiologically noticeable because the risk of CKD is strictly age-related and thus, the need for an indirect estimation of GFR increases with age. Thus, pending the need of a direct validation of the CKD-EPI formula in the elderly, present findings might be interpreted as an indirect one. Furthermore, it should be observed that we dealt with a population discharged from an acute care medical hospital and thus, with a higher early risk of death [27]. The fact that CKD-EPI also outperformed to some extent MDRD in the early follow-up testifies to its intrinsic quality.

This study has several limitations. First, the indirect validation of a formula cannot substitute for the direct one, but merely provides proxy information on the validity of the formula. Second, the 1-year follow-up and the related mortality (13%) did not allow the prognostic potential of the formulas to be optimally explored. Nevertheless, the fact that predictivity was well evident in this scenario is an indicator of the quality of the tested formula. Third, we excluded patients for whom body weight was not available in order to obtain the CG-BSA-based computation of GFR and then, to compare the three formulas. It is likely that excluded patients were the most disabled and then, difficult to weigh. Given that disability was a major predictive factor, this might have introduced a selection bias affecting the comparison. Thus, the observed predictive power of the CKD-EPI formula might not extend to a more disabled population. Finally, because of its limited power, this study may lack precision in estimates of the associations observed. Indeed, while adjusting for potential confounders blunted the significance of the association between CG-BSA and mortality, the HR values for CG-BSA and CKD-EPI were similar.

This study also has some strengths, first of all the mean age (80 years) of the studied population and the broad array of confounding factors for which the GFR–survival relationship has been corrected. In particular, the adjustment for cognitive and physical performance guarantees for the quality of results, given that disability and cognitive impairment are major prognostic factors in frail elderly [28,29].

In conclusion, this study shows that GFR adds to predictors of mortality in an elderly population discharged from acute care medical wards and that GFR <30 mL/min/1.73 m^2 cut-off marks the highest risk when computed by the CG-BSA formula, likely because CG equation to some extent incorporates the effects of malnutrition, while the best grading of GFR values with regard to mortality is achieved by the CKD-EPI-based GFR. In the absence of a formal validation study in frail patients, we could not verify whether the latter finding reflects a more accurate estimate of GFR by CKD-EPI. Nevertheless, it seems worthy of confirmation in wider populations as well as with regard to other CKD-related health outcomes such as incident disability and adverse drug reactions. Indeed, identifying elderly subjects at higher risk of adverse health events has important clinical and epidemiological implications. Present data suggest that GFR could enrich the list of predictors of interest in elderly and frail populations and pave the way to the characterization of GFR estimating formulas versus major health outcomes.

Acknowledgements. The PVC study was partially supported by a grant from the Italian Ministry of Health (RF-INR-2005-127640).

Conflict of interest statement. None declared.

Appendix 1

List of participating centres

Coordinating centre:

A. Corsonello, M. Lucchetti, M. Di Muzio, G. Gioia Lobbia, S. Giunta, S. Garasto, C. Carbone, C. Greco, P. Fabbietti, R. Firmani, M. Nacciariti, F. Lattanzio (INRCA, Ancona and Cosenza, Italy).

Clinical centres:

INRCA Ancona—G. Cadeddu, R. Ganzetti

INRCA Appignano—E. Giannandrea, A. Marrocchi, D. Giannandrea

University of Chieti—A. Di Iorio, M. Abate, A. Leoncavallo, F. Di Giambattista

INRCA Casatenovo—E. Guffanti, E. Marchi, P. Castellotti, D. Bonardi, A. Limonta

INRCA Cosenza—B. Mazzei, L. Pranno, C. Zottola, E. Feraco, A. Madeo, R. Gallo, G. Nicotera, P. Scarpelli, A. Tarsitano, A. Gervino

University of Ferrara—S. Volpato, C. Maraldi, M. Cavalieri, G. Guerra, F. Sioulis, L. Testoni, S. Postorivo, R. Fellin.

INRCA Fermo—D. Postacchini, G. Cruciani, R. Brunelli, F. Sorvillo, M. Francavilla, R.L. Marzullo, C. Giuli

University of Messina—F. Corica, C. Nicita Mauro, G. Basile, V. Nicita Mauro

University of Modena—C. Mussi, R. Scotto, G. Salvioli
INRCA Roma—A. Scuteri, L. Masci
University Campus Biomedico, Roma—C. Pedone, F.M. Serino, R. Antonelli Incalzi

References

1. Go AS, Chertow GM, Fan D *et al*. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *N Engl J Med* 2004; 351: 1296–1305
2. Anavekar NS, McMurray JJ, Velazquez EJ *et al*. Relation between renal dysfunction and cardiovascular outcomes after myocardial infarction. *N Engl J Med* 2004; 351: 1285–1295
3. Odden MC, Shlipak MG, Tager IB. Serum creatinine and functional limitation in elderly persons. *J Gerontol A Biol Sci Med Sci* 2009; 64: 370–376
4. Corsonello A, Pedone C, Corica F *et al*. Concealed renal failure and adverse drug reactions in older patients with type 2 diabetes mellitus. *J Gerontol A Biol Sci Med Sci* 2005; 60: 1147–1151
5. Corsonello A, Pedone C, Corica F *et al*. Concealed renal insufficiency and adverse drug reactions in elderly hospitalized patients. *Arch Intern Med* 2005; 165: 790–795
6. Woo KT, Wong KS, Chan CM. Clinical trials of the past decade in the management of chronic kidney disease. *Rev Recent Clin Trials* 2009; 4: 159–162
7. Fouque D, Laville M. Low protein diets for chronic kidney disease in non diabetic adults. *Cochrane Database Syst Rev* 2009; CD001892
8. Levey AS, Greene T, Beck GJ *et al*. Dietary protein restriction and the progression of chronic renal disease: what have all of the results of the MDRD study shown? Modification of Diet in Renal Disease Study group. *J Am Soc Nephrol* 1999; 10: 2426–2439
9. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis* 2002; 39: S1–S266
10. Stevens LA, Coresh J, Feldman HI *et al*. Evaluation of the modification of diet in renal disease study equation in a large diverse population. *J Am Soc Nephrol* 2007; 18: 2749–2757
11. Levey AS, Stevens LA, Schmid CH *et al*. A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009; 150: 604–612
12. Pizzarelli F, Lauretani F, Bandinelli S *et al*. Predictivity of survival according to different equations for estimating renal function in community-dwelling elderly subjects. *Nephrol Dial Transplant* 2009; 24: 1197–1205
13. Corsonello A, Pedone C, Lattanzio F *et al*. Potentially inappropriate medications and functional decline in elderly hospitalized patients. *J Am Geriatr Soc* 2009; 57: 1007–1014
14. Corsonello A, Pedone C, Lattanzio F *et al*. Regimen complexity and medication nonadherence in elderly patients. *Ther Clin Risk Manag* 2009; 5: 209–216
15. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; 12: 189–198
16. Lesher EL, Berryhill JS. Validation of the Geriatric Depression Scale–Short Form among inpatients. *J Clin Psychol* 1994; 50: 256–260
17. Katz S, Ford AB, Moskowitz RW *et al*. Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function. *JAMA* 1963; 185: 914–919
18. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist* 1969; 9: 179–186
19. Conwell Y, Forbes NT, Cox C *et al*. Validation of a measure of physical illness burden at autopsy: the Cumulative Illness Rating Scale. *J Am Geriatr Soc* 1993; 41: 38–41
20. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976; 16: 31–41
21. Levey AS, Greene T, Kusek JW *et al*. MDRD Study Group. A simplified equation to predict glomerular filtration rate from serum creatinine. *J Am Soc Nephrol* 2000; 11: A0828
22. Mosteller RD. Simplified calculation of body-surface area. *N Engl J Med* 1987; 317: 1098
23. Pedone C, Semeraro R, Chiurco D *et al*. Reliability of equations to estimate glomerular filtration rate in the very old. *Aging Clin Exp Res* 2008; 20: 496–502
24. Flicker L, McCaul KA, Hankey GJ *et al*. Body mass index and survival in men and women aged 70 to 75. *J Am Geriatr Soc* 2010; 58: 234–241
25. Matsushita K, Selvin E, Bash LD *et al*. Risk implications of the new CKD Epidemiology Collaboration (CKD-EPI) equation compared with the MDRD Study equation for estimated GFR: the Atherosclerosis Risk in Communities (ARIC) Study. *Am J Kidney Dis* 2010; 55: 648–659
26. White SL, Polkinghorne KR, Atkins RC *et al*. Comparison of the prevalence and mortality risk of CKD in Australia using the CKD Epidemiology Collaboration (CKD-EPI) and Modification of Diet in Renal Disease (MDRD) Study GFR estimating equations: the AusDiab (Australian Diabetes, Obesity and Lifestyle) Study. *Am J Kidney Dis* 2010; 55: 660–670
27. Sleiman I, Rozzini R, Barbisoni P *et al*. Functional trajectories during hospitalization: a prognostic sign for elderly patients. *J Gerontol A Biol Sci Med Sci* 2009; 64: 659–663
28. Keeler E, Guralnik JM, Tian H *et al*. The impact of functional status on life expectancy in older persons. *J Gerontol A Biol Sci Med Sci* 2010; 65: 727–733
29. Vazzana R, Bandinelli S, Lauretani F *et al*. Trail Making Test predicts physical impairment and mortality in older persons. *J Am Geriatr Soc* 2010; 58: 719–723

Received for publication: 4.7.10; Accepted in revised form: 14.9.10