GFR estimation

Glomerular filtration rate (GFR) is the usual method for measuring renal excretory function. Most commonly it is estimated (eGFR), or sometimes surrogates are used such as creatinine clearance (CrCl). Occasionally it is formally measured.

Normal values for GFR

120±25 mls/min (95th centiles. Males approx 5mls higher, females approx 5mls lower). Therefore values >90 are normal for all. Converting for average surface area (per 1.73m^2) removes the sex difference.

With age, GFR tends to fall (to approx 100mls/min/1.73m^2 at age 70), although serum creatinine does not rise much in healthy individuals (Fliser et al, Kidney Int 51:1196-1204, 1997). This fall is mostly due to subclinical pathology.

Estimating GFR

A variety of methods have been used. All are based on serum creatinine estimations. Although the Cockcroft-Gault formula is widely used, it was developed to permit estimation of CrCl, not GFR. The best validated method until recently came from the **MDRD study** data (*Ann Int Med*130:461-70, 877-84, 1999). The study derived a number of equations. The abbreviated, or four-variable equation includes age, sex, creatinine, and race (black or not black). Adding more variables (albumin, urea) adds little to accuracy.

The CKD-EPI equation (ref) is more accurate at higher GFRs than the MDRD equation.

It is important to be aware of the limitations of these equations (>more info on eGFR from the UK CKD eGuide):

- **Accuracy** – the confidence limits are wide. For MDRD 90% of values are within 30% of the true value; 98% within 50%.
- **Extremes** – none of the methods for estimating GFR without actual measurements of it are likely to be accurate in extreme examples of low muscle mass, or other unusual circumstances.
- **Stability** – for all methods, [creat] must not be changing quickly.

- **Systematic errors** – accuracy is better at low GFRs.
- **Age** – the Schwartz or Counahan Barrat equation (requires height) should be used in children.
- **Race, different equations** – more info

Most UK labs now report eGFR when returning creatinine values. When available, these values should be more accurate than calculations performed by you, as they should incorporate lab-specific correction factors. If not, here are some resources:

- Online MDRD calculator from Patient.info (SI units only, nice and simple)
- CKD-EPI calculator from Kidney Health Australia (SI units only, nice and simple)
- Online calculator from nephron.com – option of SI units or quaint mg/dl; shows results of alternative calculations including CKD-EPI and MDRD; even pointless Cystatin C variants. Take care to set units for [creat] correctly.

Measuring GFR

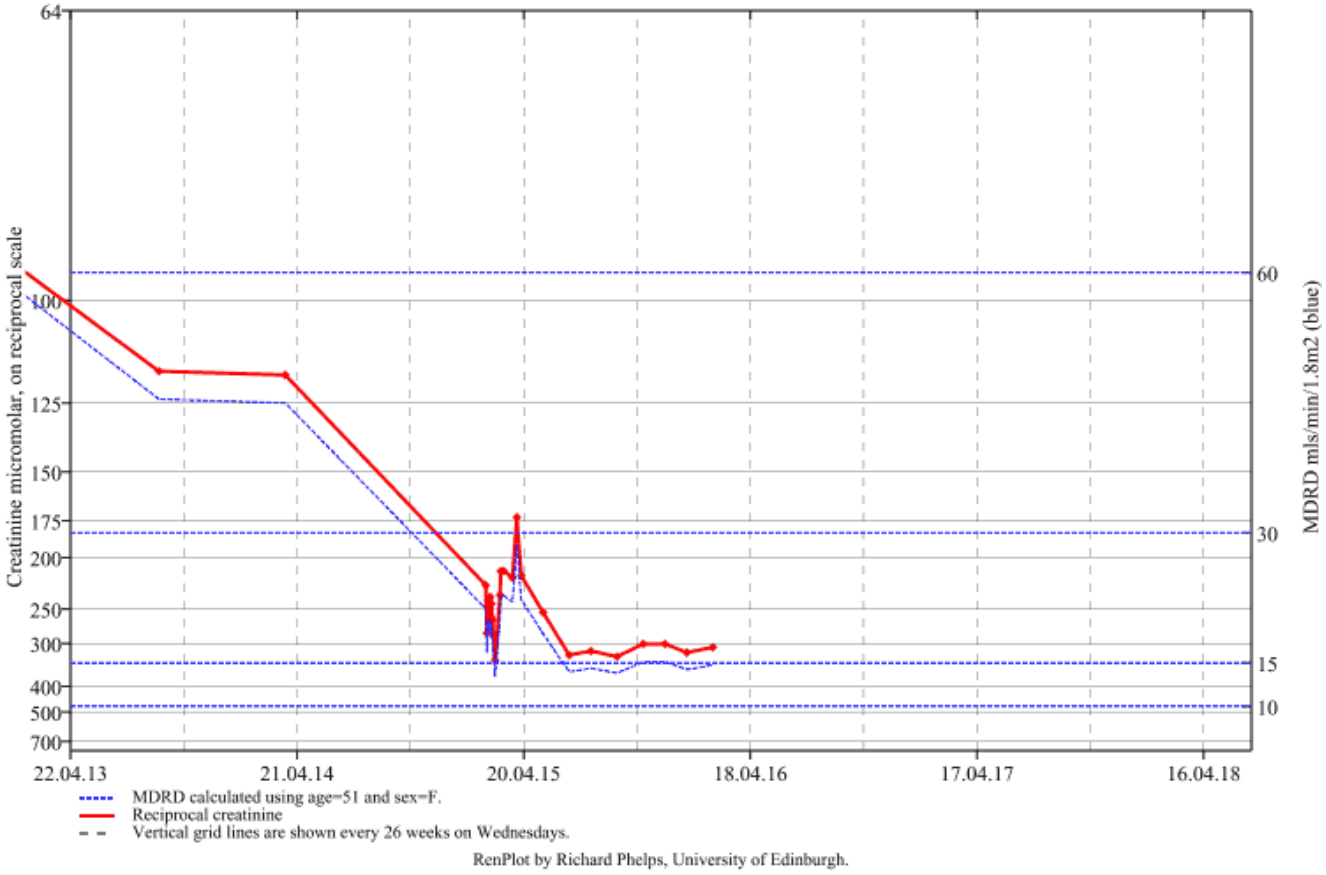
For direct measurement of GFR, isotope tests are most commonly used. Like inulin, or the radiographic contrast agent iohexol, these markers (eg 51Cr-EDTA, 99Tc-DTPA) are cleared almost entirely by glomerular filtration, and measures of their disappearance rate from the circulation, or appearance in the urine, can be used to estimate GFR.

GFR and Reciprocal of creatinine plots

Plots of GFR: time, or of the reciprocal of creatinine are useful as they can be used to give an approximate prediction of the date of ESRF for many patients, and to identify changes in the rate of progression. The rate of creatinine production in an individual changes slowly if at all. Note that linear plots of GFR/time are almost identical to reciprocal creatinine plots.

Download a blank reciprocal creatinine plot (pdf file) but note that plots of GFR vs time should be linear and in the future will probably replace 1/creatinine.

An example of a reciprocal creatinine plot for a patient with an original diagnosis of small vessel vasculitis:



Creatinine Clearance

Creatinine clearance over estimates GFR in a variety of circumstances, because of tubular secretion. This is particularly important at low levels of GFR. To calculate it, pay close attention to units and remember that there are 1440 minutes in 24h (details of calculations below). However 24 hour urine collections are error-prone and have been shown to be less accurate for estimating GFR than deductions from plasma creatinine.

Calculations: everyone knows it's UV/P but the units get a little confusing. This formula shows SI units.

UV	Amount of creatinine in 24h of urine is reported by the lab in mmol/24h. x1000 to convert to micromols
P	Serum creatinine is reported in micromols/l. x1000 to do calculation for mls
1440	Number of minutes in 24h

Estimating CrCl

The **Cockcroft-Gault equation** aims to predict creatinine clearance from

knowledge of serum creatinine, age and weight. See Calculator 2 (mentioned above) or do it the hard way:

$$\frac{(140-age) \times weight\ (kg) \times 1.23 \times (0.85\ if\ female)}{Creat\ [micromol/l]}$$

Weight should be lean body mass, but attempting to calculate that makes the equation unreasonably complicated. Estimate lean body mass for extremes of size, or use the MDRD equation instead, or best of all, measure it.

Note that these estimates/measures of CrCl are not normalised for body size, if you want to compare with eGFR you should adjust according to calculated surface area.

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