Student version

Clearance

Bruce M. Koeppen, M.D., Ph.D.
University of Connecticut Health Center

1. Inulin is used in an experiment to measure the glomerular filtration rate (GFR). Inulin is continuously infused to achieve a steady-state concentration in the plasma of 1.0 mg/dL. Urine is collected over a 10 hour period. The total volume of urine is 1.5 L, and the urinary concentration of inulin is 440 mg/L. What is the GFR, as determined from the inulin clearance?

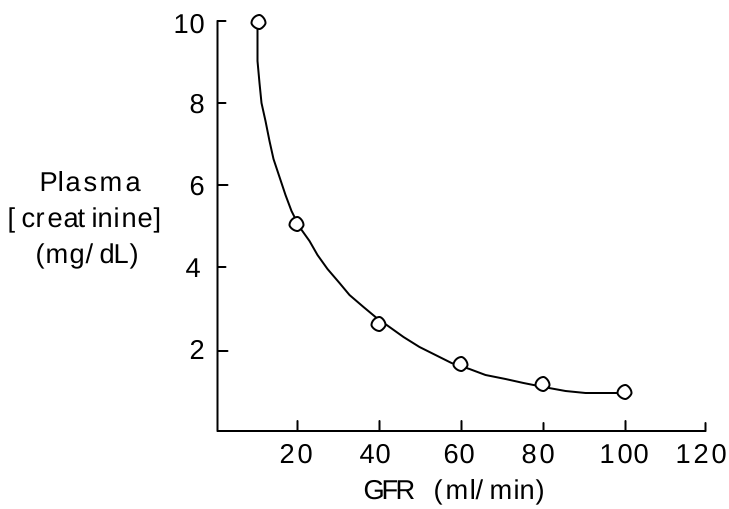
   Inulin Clearance = GFR = ___________ ml/min

2. In clinical situations the GFR of a patient is usually determined by measuring the clearance of creatinine. Like inulin, creatinine is freely filtered at the glomerulus. However, in contrast to inulin, a small amount is also secreted (approximately 10% of all creatinine excreted in the urine reflects this secretory component). Therefore creatinine is not an ideal marker for GFR. Despite this error, creatinine is used to measure GFR because it is produced endogenously by skeletal muscle, and does not require an infusion. Therefore it is easy to do a creatinine clearance, because the patient can do it at home by simply collecting their urine (usually over a 24 hr period), and having a single blood sample obtained to measure the plasma [creatinine]. What would be the estimated GFR of a patient with the following values for plasma and urine [creatinine] and urine volume.

   Plasma [creatinine] = 1.5 mg/dL
   Urine volume = 1.5 L/24 hours
   Urine [creatinine] = 1.44 gm/L

   Creatinine Clearance? GFR = ___________ ml/min

3. One important consequence of renal disease is loss of nephrons. As nephrons are lost the GFR will decrease (remember that GFR is the sum of the filtration rates of all the nephrons in the kidneys). Therefore, as renal disease progresses the GFR declines, and the plasma [creatinine] increases. The relationship between GFR and plasma [creatinine] is illustrated below.



How do you explain the shape of this relationship, and what limitations does this present when trying to estimate GFR from a single plasma creatinine value?

4. A 25 year old man weighing 60 kg has a plasma [creatinine] of 1.4 mg/dL (nl = 0.8 - 1.4 mg/dL). A 24 hour urine collection is done to determine his creatinine clearance, and thereby estimate his GFR. The following data are obtained:

Urine [creatinine] = 833 mg/L
Urine volume = 1,080 ml/24 hour

What is his creatinine clearance?

Creatinine clearance = ___________ ml/min

If the normal range of GFR for adult males is 90 - 140 ml/min, what would you conclude about the renal function of this man?

What error could lead to the calculation of a creatinine clearance that does not reflect the actual GFR? How could you determine if such an error occurred in this man, without having to repeat the 24 hour urine collection? (*Hint*: Muscle creatinine production is relatively constant and proportional to muscle mass. In adult males, the creatinine production rate is 20 -25 mg/kg body weight/day, and in adult females it is 15 - 20 mg/kg body weight/day).

5. The renal handling of Na^+ and K^+ and urea are examined in two individuals. Both individuals eat the same diet, and are in steady-state balance. However, they have different glomerular filtration rates. Subject A has a GFR of 170 L/day, while the GFR of subject B is 50 L/day. The following data are obtained.

Subject	Na^+ Intake mEq/day	K^+ Intake mEq/day	Urea Production gm/day	GFR L/day	Urine Flow L/day
A	100	50	8.5	170	1
B	100	50	8.5	50	1

Subject	Serum [Na^+] mEq/L	Serum [K^+] mEq/L	Serum BUN* mg/dL	GFR L/day

A	145	3.5	10	170
B	145	3.5	34	50

*BUN = blood urea nitrogen

Assume that the kidneys represent the only excretion route for Na^+, K^+ and urea. Calculate the following:

	Subject A	Subject B
Clearance		
Na^+ (L/day)	________	________
K^+ (L/day)	________	________
Urea (L/day)	________	________
Filtered Load		
Na^+ (mEq/day)	________	________
K^+ (mEq/day)	________	________
Urea (mg/day)	________	________
Fractional Excretion		
Na^+ (%)	________	________
K^+ (%)	________	________
Urea (%)	________	________
Tubular Reabsorption		
Na^+ (mEq/day)	________	________
K^+ (mEq/day)	________	________
Urea (mg/day)	________	________

Based on the above data, explain each of the following:

A. Why are the clearances of Na^+ and K^+ the same in subjects A and B, but the clearance of urea different?

B. Why do the filtered loads of Na^+ and K^+ differ in subjects A and B, but the filtered load of urea is the same?

C. Why are the serum concentrations for Na^+ and K^+ the same in subject A and subject B, but the serum BUN concentration is greater in subject B than in subject A?

D. How do you explain the differences in fractional excretion and tubular transport of Na^+, K^+ and urea?

