Nomograms\(^1\) for Calculation of Urea Clearance

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Two nomograms are given for use in calculating standard, \(C_n\), or maximum, \(C_m\), urea clearance. The first nomogram calculates the urine flow rate, \(f\), from the urine collection time and volume data. With the second nomogram, values of \(f\) and urea nitrogen concentrations in blood serum (or plasma) and urine are used to calculate either \(C_n\) or \(C_m\), according to the value of \(f\). There is no intermediate calculation of \(\sqrt{f}\). Examples of the use of the two nomograms in the calculation of \(C_n\) or \(C_m\) are given.

Urea clearance determination has long been used as a valuable criterion of renal function (\(1, 2\)). Its calculation is complicated by the use of two different equations for the calculation of the two quantities, \(C_m\), the maximum urea clearance, and \(C_n\), the standard urea clearance. These two well known quantities are defined by the equations

\[
C_m = \frac{Uf}{S} \quad \text{and} \quad C_n = \left(\frac{U}{S}\right)\sqrt{f},
\]

where \(S\) is the serum (or plasma) urea nitrogen concentration (mg/100 ml), \(U\) is the urine urea nitrogen concentration (mg/100 ml), and \(f\) is the urine flow rate (in ml/min).

Henry (\(1\)) has discussed the background and reviewed the use of these equations. \(C_m\) is calculated when \(f \geq 2\) ml/min and \(C_n\) is calculated when \(f < 2\) ml/min.

The above calculations, especially that of \(C_n\), are time consuming, especially since automated methods for the determination of urea nitrogen (\(3\)) may require less technician time for the determination of \(U\) and \(S\) than for the calculation of \(C_m\) or \(C_n\). The present nomograms permit the calculation of \(C_m\) or \(C_n\) faster than is possible with a slide rule or a desk calculator. The use of nomograms also avoids decimal point errors, perhaps the most common pitfall in the clinical laboratory use of the slide rule.

Two nomograms are required (Figures 1, 2) for the calculation of urea clearance. The first (Figure 1) converts the collection timing data and volume of the urine specimen into the flow rate, \(f\). The second nomogram (Figure 2) converts the set of \(U\), \(S\), and \(f\) values into \(C_m\) or \(C_n\), by the use of the appropriate sections of its \(f\)-scale. The principles used to construct the nomograms have been given earlier (\(4, 5\)).

Fortunately, there is a large gap in the \(f\)-scale of Figure 2, corresponding to the separation between \(f\) at the upper part of the scale, and \(\sqrt{f}\), at the lower part of the scale. The gap is at \(f = 2\) ml/min. This readily permits the user of the nomogram to see if \(C_m\) or \(C_n\) is being calculated. As a further aid in making the distinction,

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Fig. 1. First nomogram, for calculation of urine flow rate. First two axes are graduated in 10-min intervals.
first nomogram, a straight line is drawn between the time finished and time started axes and extended until it intersects the elapsed time axis (at 2.9 h, but this need not be recorded). A second straight line is then drawn from the intersection of the first straight line with the elapsed time axis and the 275-ml urine volume on the urine volume axis. This second straight line intersects the inclined f-axis at 1.58 ml/min, which is the flow rate.

Since the flow rate, \( f = 1.58 \text{ ml/min} \), is less than 2 ml/min, \( C_s \) is to be calculated. Analysis of the corresponding blood serum and urine specimens shows \( S = 19 \text{ mg/100 ml} \) and \( U = 250 \text{ mg/100 ml} \). Using the second nomogram, a straight line is drawn between \( U \) and \( S \) and is extended to the \( U/S \) axis (which it intersects at \( U/S = 13.2 \), but this is not recorded). A second straight line is drawn between the intersection of the first straight line with the \( U/S \) axis and \( f = 1.58 \text{ ml/min} \). The second straight line intersects the urea clearance axis at \( C_s = 17\sqrt{\text{ml/min}} \).

Using a slide rule and desk calculator, I found that \( C_s = 16.5 \sqrt{\text{ml/min}} \). The two values of \( C_s \) are close enough for practical purposes; the two nomograms evidently give the correct value of \( C_s \) within a few percent.

Example B (Figure 4): A 315-ml urine specimen was collected from patient B, starting at 8:05 a.m. and finishing at 10:20 a.m. With the first nomogram, I find that \( f = 2.34 \text{ ml/min} \), so that \( C_m \) is to be calculated. Analysis of the corresponding blood serum and urine gave \( S = 11 \text{ mg/100 ml} \) and \( U = 370 \text{ mg/100 ml} \).

On the second nomogram, a straight line be-
between \( U = 370 \text{ mg/100 ml} \) and \( S = 11 \text{ mg/100 ml} \) is extended to the \( U/S \) axis (intersecting it at \( U/S = 33.7 \), a value which is not necessary to record). A second straight line is drawn between the intersection of the first straight line with the \( U/S \) axis and \( f = 2.34 \text{ ml/min} \). The resulting value of \( C_m = 79 \text{ ml/min} \). A slide rule gives \( C_m = 78.7 \text{ ml/min} \).

The nomogram of Figure 1 is set for use during the morning hours, the usual time for urea clearance determinations. The nomogram may be easily converted for use during other parts of the day by adding the same number of hours to each number listed on the time started and time finished axes. Thus, on the addition of 7 h to each number, the first axis would go from 12:30 p.m. to 4 p.m. and the second axis from 12:30 p.m. to 7 p.m., a suitable range for afternoon patients.

There are several points of resemblance between the nomogram of Figure 2 and my earlier nomogram for the calculation of creatinine clearance (6). Figure 2 is unique only in that it permits calculation of \( C_m \) or \( C_s \) with the least effort. The creatinine clearance nomogram may be used for the calculation of \( C_m \) over many hours when the flow rate exceeds 2 ml/min after changing some of the numbers, as noted in the earlier paper. It is sometimes worthwhile to determine both urea and creatinine clearance with the same set of specimens.

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References