The concept of clearance: an alternative teaching-learning method

Edson Delattre

Department of Structural and Functional Biology, Institute of Biology, University of Campinas, Campinas, Brazil

Submitted 19 February 2013; accepted in final form 1 May 2013

IN SIMPLE TERMS, clearance is the removal of a substance from the blood (1). A physiologist uses the concept of clearance to describe the net result of transport functions of the kidney. The clearance of a substance is the amount removed from plasma divided by the average plasma concentration over the time of measurement. It can be thought of as the volume of plasma that can be completely cleared of the substance in a unit of time. Clearance is also a useful concept when describing the process of dialysis (2).

In teaching-learning activities, the need for increased balance between qualitative (logical reasoning, without the presentation of new specific and elaborate mathematical equations) and quantitative aspects (ready specific equations) has already been demonstrated.

Unfortunately, the development of theoretical teaching is often achieved through the use of a succession of mathematical equations (equation-based knowledge) rather than a logical explanation of phenomena. From elementary school through higher education, students who frequently apply equations and obtain numerically accurate results still experience serious difficulties when attempting to provide a logical explanation for phenomena.

Teaching the concept of clearance poses some difficulty, as it comprises an intrinsic virtual aspect. In regard to this matter, physiology textbooks customarily present ready equations, which not only do very little to enlighten students but also tend to confuse them.

With a view to assisting beginner students in understanding the concept of clearance, we added a pedagogical technique to our classes. We presented questions, the answers to which led to the determination of the value of clearance. Hence, the central question is as follows: What is the volume of plasma required to supply the amount of substance X excreted in urine during the period of 1 min? Answering this question therefore means determining clearance. For that purpose, the basic parameters are 1) diuresis (volume of urine produced per minute), 2) the concentration of the substance in urine (in mg/ml), and 3) the concentration of the substance in plasma (in mg/ml). Based on these data, handled in two stages, the student will infer the value of clearance, using logical reasoning alone.

In the first stage, the student answers the following question: What is the amount of substance X excreted per minute in urine? To that end, they apply the following simple calculations:

1 ml urine ----------------------- x (in mg)

Diuresis per minute ------- y (in mg)

Therefore,

\[ y = \frac{[\text{diuresis per minute} \times x (\text{in mg})]}{1 \text{ ml urine}} \]

The student thus obtains the amount of the substance excreted in urine (y; in mg) during the period of 1 min.

In the second stage, the student answers the main question, i.e., what is the volume of plasma required to supply the amount of substance X excreted in urine during the period of 1 min? Again, through the application of the following simple calculations, the student is able to determine the volume of plasma (z) required to supply the amount (y; in mg) excreted during the period of 1 min:

1 ml of plasma ------------------------ x (in mg)

z ml of plasma ------------------------ y (in mg)

Therefore,

\[ z \text{ (in ml/min)} = \frac{[1 \text{ ml of plasma} \times y (\text{in mg})]}{x (\text{in mg})} \]

Hence, the value of z represents the virtual volume of plasma that would have been totally depurated from the substance in the period of 1 min. Expressed in milliliters per minute, this represents the clearance of substance X.

As an example, suppose that a 0.50 mg/ml concentration of hypothetical substance X (e.g., urea) is found in plasma, that its urinary concentration is 25 mg/ml, and that diuresis is 1.2 ml/min. We can therefore determine the following:

1 ml urine ------------------------ 25 mg

1.2 ml urine ------------------------ y

Thus, y = 30 mg (excreted amount per minute)

1 ml plasma ------------------------ 0.50 mg

z ------------------------ 30 mg

Thus, z = 60 ml (virtual volume of plasma depurated from this substance per minute)

Therefore, the clearance of hypothetical substance X is 60 ml/min.

The present procedure, conducted in stages, enables the student to develop logical reasoning while performing mathematical calculations, which differs from the literal application of the traditional mathematical formula for the calculation of clearance (C = UV/P, where C is clearance, U is the concentration of substance X in urine, V is urinary volume, and P is the concentration of substance X in plasma). In this manner, the impact generated by the presentation and application of a new, specific, and contextual formula is replaced by the intuitive and gradual discovery of the concept of clearance and its calculation, which is now carried out using a trivial formula already known by students.

Although results obtained through the use of this method have not been quantitatively evaluated, we consider them to be satisfactory in terms of the high level of interest and participation they generated in students during the presentation of this matter.

On that account, we conclude that the procedure presented in this work can advantageously replace the mechanical application of the traditional calculation of clearance, which fails to make logical sense to beginner students, on its own.
DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: E.D. conception and design of research; E.D. analyzed data; E.D. interpreted results of experiments; E.D. drafted manuscript; E.D. edited and revised manuscript; E.D. approved final version of manuscript.

REFERENCES