Committee on Drugs

SI Units

Le Systeme International d'Unites or SI units is a system of measure that is an outgrowth of the metric system, widely used in countries other than the United States.[1] This system comprises seven base units from which all other measurements are made (Table).

The aim of SI units is to (1) provide a coherent system of measure, (2) ensure that quantities and units are uniform in concept and style, and (3) minimize the number of multiples and submultiples in common use.[1] A more complete review of metrification and SI units has been published in this journal.[2]

The conversion to SI units was mandated in December 1984 by the American Medical Association House of Delegates to "provide physicians and other scientists in the United States with an improved common language for fluent scientific communication between nations as well as between sciences."[3]

In several published articles there have been suggestions that the United States should, during the next year, begin uniformly reporting laboratory test data in SI units, including drug concentrations in molar units.[3,4] Although drugs would continue to be prescribed in mass units,[4] the desirability of prescribing and dispensing drugs in molar units has been suggested.[3]

The focus of this commentary is to summarize the problems and inconsistencies of expressing drug concentrations in molar units, assuming that prescribing and dispensing would continue in mass units.

PHARMACOKINETIC CALCULATIONS

In a recent study tenfold dosing errors were demonstrated, resulting from mathematical miscalculations while using traditional units.[5] The introduction of additional calculations for conversion to SI units, and the fact that SI units involve decimal places with several significant figures, will likely magnify this type of error.[6]

Simple pharmacokinetic calculations become more difficult and involve an additional calculation when the drug concentration is reported in SI units and drug doses are administered in mass units. Either SI units must be converted to traditional values to use existing pharmacokinetic formulas (Appendix) or new pharmacokinetic constants or formulas accommodating SI units must be developed.[7]

One could hypothesize that measuring or prescribing in SI units would somehow better relate drug plasma concentration to drug receptor interactions. Conversion factors for interconverting SI units and traditional units vary by a factor of 10, depending on which traditional or SI unit is used. The use of the incorrect conversion factor can result in dosing errors (Appendix). However, the relationship between drug plasma concentration and pharmacologic effect is independent of the units in which the concentration is expressed.

DUAL UNITS OF MEASURE

Even when the SI system is used, dual units of measure will always be necessary. Some drugs are a mixture of substances and, therefore, have no specific molecular weight. Drugs such as gentamicin, insulin, heparin, and bleomycin cannot be expressed in SI units.[8]

A solution to this inconsistency is the measurement of drug doses and drug plasma concentrations in the same units. Although some authors have expressed interesting in converting drug doses to SI units,[3] this solution could cause confusion and inconvenience to health care providers as well as patients.[8] An amoxicillin dose of 40 mg/kg would become 0.095 mmol/kg, and a 125-mg tablet of erythromycin would become a 0.1703-mg tablet.

Adopting molar units for drugs would not improve world standardization. Few countries have changed to molar units for expressing drug concen-

The recommendations in this statement do not indicate an exclusive course of treatment or procedure to be followed. Variations, taking into account individual circumstances, may be appropriate.

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TABLE. SI Units

Quantity	Name	Symbol
Amount of substance	Mole	mol
Electric current	Ampere	A
Energy*	Joules	J
Length	Meter	m
Luminous intensity	Candela	cd
Mass	Kilogram	kg
Pressure*	Pascal	Pa
Thermodynamic temperature	Kelvin	K
Time	Second	s

* Base and two derived units.

trations, and drugs are not prescribed in molar doses in any country.[8]

COST

The cost of converting a single institution or institutions throughout a geographic area from traditional units to SI units has not been adequately addressed. It has been stated by McQueen[1] that the cost of conversion to SI units in the Canadian provinces was minimal. Few instruments required adjustment; when change was required, manufacturers made any necessary modifications at no charge.[9] However, there are additional costs that involve changes in computer programming, as well as reeducation of medical personnel and patients. The impact of these costs has not been adequately addressed.

RECOMMENDATION

Pediatricians and other health care providers should familiarize themselves with issues surrounding SI units and be aware of the implications of and time frame for conversion of clinical chemistry results in the laboratories that they use. For the previously stated reasons, drug concentrations should continue to be reported in mass units until the benefits for pediatric patients of such a conversion can be demonstrated.

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Appendix*

SI UNIT EXAMPLE

A 10-kg 1-year-old child's phenytoin serum concentration is reported to be 35 μmol/L (therapeutic range 39–79 mol/L)

A concentration of 75 μmol/L is desired

To Calculate:

$D = Cp \times V_D$

$V_D = 0.8\ L/kg \times 10\ kg = 8\ L$

Additional Calculation:

Must be done because dose of drug is in mg not μmol

$$\text{Traditional Unit} = \frac{\text{SI Unit}}{\text{CF}}$$

$$\text{Traditional Unit} = \frac{75\ \mu mol/L}{3.964} = 19\ \frac{\mu g}{mL}$$

$$Cp = \frac{19\ \mu g}{mL} = \frac{19\ mg}{L}$$

$$D = \frac{19\ mg}{L} \times 8\ L = 152\ mg$$

The child was receiving 70 mg. An additional 82 mg (152 mg − 70 mg = 82 mg) dose is needed.

* D, dose; V_D, volume of distribution; Cp, plasma concentration; L, liter; kg, kilogram; μmol, micromole; mg, milligram; μg, microgram; CF, conversion factor.

The use of the incorrect conversion factor (decimal point error) (0.3964) would result in a "calculated Cp" of $\frac{190\ \mu g}{mL}$

$$D = \frac{190\ mg}{L} \times 8\ L = 1{,}520\ mg$$

resulting in an additional dose of 1,450 mg being administered.

Traditional UNIT EXAMPLE

A 10-kg 1-year old child's phenytoin serum concentration is reported to be 8.8 μg/mL (therapeutic range 10–20 μg/mL)

A concentration of 19 μg/mL is desired

To Calculate:

$D = Cp \times V_D$

$V_D = 0.8\ L/kg \times 10\ kg = 8\ L$

$$Cp = \frac{19\ \mu g}{mL} = \frac{19\ mg}{L}$$

$$D = \frac{19\ mg}{L} \times 8\ L = 152\ mg$$

The child was receiving 70 mg. An additional 82 mg (152 mg − 70 mg = 82 mg) dose is needed.

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