International nomenclature for clinical chemical quantities

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Introduction

It may seem strange, to start a symposium on quality control with a talk on quantity names and units. It is evident however, that we cannot hope to control quality, if we are not able to specify what we are trying to control. With increasing sophistication of clinical chemistry this specification has become more difficult and also more necessary - especially since quality control is now of international scope and involves specialists from many disciplines.

To this date the way of presenting clinical chemical data has been incredibly diverse, inconsistent, and often incomprehensible to outside colleagues. This, sometimes, leads to dangerous mistakes.

I have met with an instance where a clinician suggested bleeding in a patient having a blood hemoglobin mass concentration of 135 grammes per litre because he thought that the result was given as per cent of a normal mean.

Additionally, the conventions have been contrary to internationally accepted terminology used in other branches of science, notably chemistry, biochemistry, and physics, with which clinical chemistry must communicate.

Recognizing the chaos in the clinical chemical language, international efforts in 1966 created a first *Recommendation on Quantities and Units* with the approval of the International Union of Pure and Applied Chemistry and of the International Federation of Clinical Chemistry ([1-3]).

Recommendation 1966

The subject matter of this recommendation may be divided in three parts: The naming principle of the parameters that are measured, the preferred way in which to express them, the units to be used.

Concerning names three parts are necessary: system, component, and kind of quantity. The system may be the blood serum of a stated patient at a stated moment; the component could be the sodium ions of the serum, and the kind of quantity would be the way in which the component should be related to the system, e. g. the mass concentration or the molar concentration of the sodium ions in the serum. The full set of information is called the quantity name.

The preferred way of relating component and system, when a choice is possible, is that giving the best information in a given situation. Is it better to express the concentration of sodium ion in serum as mass concentration or molar concentration? Should the concentration of hemoglobin in blood be given as molar concentration or mass concentration or as per cent of normal? Here, it seems evident that the « molecular » concepts possess inherent advantages which decide the issue. Mass and mass concentration very seldom correlate component and system in a biologically useful way, whereas normal and pathological biochemical processes are governed by laws that are molecular in nature. Thus, « molecular concepts » clarify functional relationships, « mass concepts » obscure them. This fact is mostly reflected today by the use of molar concentration or « equivalent concentration » in the field of inorganic electrolyte concentrations in serum, i. e. for the components sodium-ion, potassium-ion, chloride, and hydrogen carbonate. A short list of other groups of interrelated components should show the advantages of extending this usage:

acetoacetate – acetone – β-hydroxybutyrate;
adrenalinium – noradrenalinium – 4-hydroxy-3-methoxymandelate;
« base excess » – lactate – glucose;
bilirubin – bilirubin conjugates – albumin;
calcium(II) – phosphate;
chloride – bromide;
cholesterol – cholesterol esters;
glycerol – triglycerides;
hemoglobin(Fe) – dioxygen(O_2) – iron(II) – transferrin.

Consequently the International Federation of Clinical Chemistry (IFCC) recommends the use of quantities of a « molecular nature » whenever possible.

As far as units are concerned a set of seven or eight kinds of quantities and corresponding units (Table 1) is regarded as basic, whereas all other quantities and units are derived from this set by simple equations, e. g. volume is length to the third power. When the base units have an inconvenient size, subunits are created by the use of a list of internationally approved factors having step « heights » of one thousand (Table 2). This means that the volume denominator often used for concentration units « one hundred millilitres » is abandoned.

TABLE 1

International basic kinds of quantities and corresponding base units

BASIC KIND OF QUANTITY		BASE UNIT	
Name	Symbol	Name	Symbol
length	*l*	metre	m
mass	*m*	kilogramme	kg
time	*t*	second	s
electric current	*I*	ampere	A
thermodynamic (absolute) temperature	*T*	kelvin	K
luminous intensity	*I*	candela	cd
amount of substance	*n*	mole	mol
« amount of enzyme » *	—	enzyme unit	U

* Cf. « Added in proof ».

TABLE 2

Names and symbols of factors placed before unmultiplied units

PREFIXES SYMBOLIZING FACTORS					
Factor	Name	Symbol	Factor	Name	Symbol
			10^{-3}	milli-	m
			10^{-6}	micro-	μ
10^{12}	tera-	T	10^{-9}	nano-	n
19^{9}	giga-	G	10^{-12}	pico-	p
10^{6}	mega-	M	10^{-15}	femto-	f
10^{3}	kilo-	k	10^{-18}	atto-	a
10^{2}	hecto-	h	10^{-1}	deci-	d
10^{1}	deca-	da	10^{-2}	centi-	c

The recommended system may be illustrated by mentioning a few kinds of quantities and examples of their use.

For *volume* the simplest, so-called coherent unit is the cubic metre, but IFCC has decided — for the time being — to prefer the litre and its subunits, e. g.:

Patient--Urine, volume = 1.20 l

The kind of quantity *mass* should not be confused with « weight », e. g.:

Patient--Body, mass = 70.0 kg

Amount of substance is the new « chemical » basic kind of quantity with the base unit *mole* (defined as the amount of substance of a given component

which contains as many formula units as there are atoms in exactly 0.012 kg of the pure carbon nuclide ^{12}C), e. g.:

24 hours Urine--Calcium(II), amount of substance = 4.3 mmol/l

Mass concentration is used only when « molecular » kinds of quantities will not serve, e. g.:

Serum--Lipid(total), mass concentration = 7.0 g/l

Amount of substance concentration (molar concentration) should be used whenever possible, e. g.:

Blood--Hemoglobin(Fe), molar concentration = 8.9 mmol/l

Particle concentration, much used in haematology, should not employ the microlitre as volume denominator.

Blood--Leukocytes, particle concentration = 6.5×10^9/l

Time does not permit discussing the many other kinds of quantities used in clinical chemistry, only the most important have been touched upon.

Implementation.

A few words should be spared on the implementation of the principles of the Recommendation.

Evidently, the use in practice of the system requires thorough education of clinicians, nursing staff, and laboratory personnel. Informatory articles, lectures, and discussions are necessary for, perhaps, half a year preceding the change. A list of names and units as well as conversion factors from former to new values should be prepared in handy format. It would be advantageous if all the laboratories in a country change at the same time, but not a prerequisite. I prefer a voluntary act, decided by a conviction that the advantages of the recommended system outweigh the problems of transition. Personally, I prefer a sudden — rather than a stepwise — change for all quantities measured. A prolonged period of transition only drags out the inevitable pain of rethinking. Incidentally, from experience I know that this pain is bearable since only about ten of the more used quantities alter the values of the results. For the rest, the users have to consult the normal ranges anyway.

The advantages of the recommended system are prominent: international and national unification in presentation of results, a common language with other scientific disciplines, biological insight and, ultimately, fewer misunderstandings.

The American Association of Clinical Chemists already adopted the Recommendation 1966 in principle. The Netherlands, Finland, Norway, and Denmark decided to change during this year. Great Britain will change stepwise. The periodicals Clinical Chemistry, Clinica Chimica Acta, and Scandinavian Journal of Clinical and Laboratory Investigation will recommend the system to the authors.

Why don't you join the club? I think it would be extremely valuable if the Italian clinical biochemists at their first National Congress decided to adopt the principles of Recommendation 1966 of IUPAC and IFCC.

Summary. — The problem of terminology in the field of clinical chemistry was faced by two International Bodies: the Section on Clinical Chemistry of the IUPAC and the International Federation of Clinical Chemistry, in order to achieve the following:

1) To reduce the number of the ways of presentation of clinical chemical results.

2) To unify the terminology used in clinical chemistry with that used in related fields.

3) To achieve increased biological insight through the preferred use of kinds of quantities of a « molecular » nature.

Therefore, a « Recommendation on Quantities and Units» was prepared in 1966, based on the recommendations of the IUPAC, IUB, IUPAP and ISO, and concerning the basic and derived quantities and the corresponding units of major importance for the clinical chemist, and particularly for his communication with clinicians.

The principles of this Recommendation are illustrated with practical examples. The adoption of a unified nomenclature on a national and international level is strongly encouraged. The advantages for both scientists and patients of reducing the possibilities of errors and misunderstandings are emphasized.

Riassunto (*Terminologia internazionale unificata per i risultati quantitativi delle analisi chimico-cliniche*). — Il problema della terminologia nel campo della Chimica Clinica è stato affrontato da due Enti Internazionali: la Sezione di Chimica Clinica della IUPAC, e la Federazione Internazionale di Chimica Clinica, con i seguenti obiettivi:

1) ridurre il numero delle modalità di presentazione dei risultati chimico-clinici;

2) facilitare il coordinamento della nomenclatura nel campo della chimica clinica e nei campi affini.

3) conseguire una più profonda comprensione biologica attraverso l'impiego di unità di natura « molecolare ».

È stata quindi approntata nel 1966, in base alle raccomandazioni della IUPAC, IUB, IUPAP e ISO, una « Recommendation on Quantities and Units» che riguarda le grandezze di base, quelle da esse derivate e le corrispondenti unità di misura di maggiore importanza per il chimico clinico, specie nei suoi rapporti con i clinici. I principi in essa contenuti vengono illustrati mediante una serie di esempi pratici.