The metric system in medicine and pharmacy / by T.B. Curtis.

"The Introduction of the International Decimal Weights and Measures."

AMERICAN METRIC BUREAU.

GENERAL OFFICES, 7 AND 8, SECOND STORY, 32 HAWLEY STREET, BOSTON.

CIRCULAR 22. — *The following article is issued separately for distribution as Circular 22, and will be sent to any physician applying. The author is the Chairman of the Bureau Committee on this subject. A brief circular, with equivalents, dangerous doses, etc., a new edition of the leaflet distributed last year, will soon be ready, and will be sent with this. This article is reprinted from the plates of the Boston Medical and Surgical Journal, and the old spelling, gramme, was then followed. Gram is now almost universally accepted as the correct spelling.*

THE METRIC SYSTEM IN MEDICINE AND PHARMACY.[1]

BY T. B. CURTIS, M. D.

We are all sufficiently familiar, in a general way, with the advantages claimed for the metric system of weights and measures. These, briefly enumerated, are: uniformity; simplicity; the decimal character; the fact that the various units have definite and readily apprehended relations to each other; a nomenclature which is self-defining and expressive of values; and, finally, security, the base being unalterable.

We also know the objections which have been raised against the proposed introduction of the metric system, and we have probably all been struck by the trivial and irrelevant character of several of them. The only objection which appears to me to possess any weight at all is one upon which our opponents habitually lay but little stress; yet it must be admitted that it has great force and deserves very careful consideration. I refer to the trouble and labor unavoidably attending any change of weights and measures. Routine, proceeding from traditions and habits of long standing and of numerous and complex ramifications, is firmly established. Is it worth our while to try to overcome the inertia of this routine? What are the inducements for us, whose main interest in the question is connected with the handling of drugs, to take a leading part in the proposed reform? In answer to this question I intend to pass in review, from the stand-point of the physician, certain advantages which can be claimed for the new system, and also to consider certain objections which have been brought forward by physicians against it.

First, it should be understood that the adoption of the metric system as used in Europe involves two separate and wholly independent innovations, consisting, primarily, in the substitution of a new system of weights and measures, with its nomenclature, for our present system; and, secondly, in the substitution of gravimetric methods for the system, partly gravimetric and partly volumetric, now in use.

With regard, in the first place, to the new system of weights and measures called the metric, this system recommends itself by several manifest merits. The advantage of uniformity with the usages estab-

[1] Read before the Suffolk District Medical Society, March 31, 1877.

lished among physicians in other countries is self-evident. In Germany and in France, which are, of all countries in which the English language is not spoken, those whose medical literature is most valuable to us, the metric system is used. In England weights and measures of the same names as ours are used, but they have different values; moreover, the English method of dealing with liquids is somewhat different from ours. All German, French, and English pharmaceutical formulas have therefore to undergo a process of translation, involving not only different weights and measures, but different methods of handling liquids, before they can be rendered available for use in this country. The adoption of the metric system, then, would bring us into agreement with the majority of civilized countries, while now we agree with none.

The metric system offers another advantage in that it provides denominations of weight applicable to the smallest quantities which the physician or the pharmacist can be called upon to prescribe or dispense. The advances achieved in chemistry and in therapeutics have provided a number of powerful drugs of which the doses are so minute as to oblige us to have recourse to very small fractions of our smallest unit of weight. The grain, which was suitable for dealing with the less powerful drugs formerly in use, is far too large a unit for the alkaloids and glucosides which modern chemistry has added to our materia medica. For handling these the centigramme and the milligramme of the metric system are eminently suitable.

Perhaps, however, the greatest advantage of the metric system accrues from the decimal character of its divisions. Some mathematicians have, I believe, asserted, on what to most of us must seem somewhat transcendental grounds, that the decimal system offers in itself no real advantage; that it has no *raison d'être* based upon any intrinsic properties of numbers or upon any mental attributes of mankind. This might possibly be true had other systems of numeration than those with which we are familiar originally been adopted. As a fact, however, our arithmetic is decimal. We count by series of tens, and higher and higher powers of ten constitute successive series of units. Hence the facility of decimal arithmetical operations. In the metric system, of which the divisions also proceed by series of tens, we change from one denomination to another, multiplying or dividing by ten, by one hundred, etc., by simply moving the decimal point to the right or to the left.

Another important advantage growing out of the arithmetical simplicity of a decimal division of our weights and measures is the readiness with which we should be enabled to appreciate quantitative ratios in our formulas and in the resulting pharmaceutical preparations. A few examples will suffice to make clear the difference in this respect between the old and the new system.

To illustrate, in the first place, the complexity and tediousness of the arithmetical processes involved in the use of our present method, and to show the difficulty of rapidly apprehending quantitative ratios, let us take the *mistura glycyrrhizæ composita*, or "brown mixture," of our Pharmacopœia. It contains the following ingredients: licorice, sugar, and gum arabic, of each ℥ss.; of camphorated tincture of opium, f℥ij.; of wine of antimony, f℥i.; of spirits of nitrous ether, f℥ss.; of water, ℥fxii. The dose for an adult is a tablespoonful, for a child two years old a teaspoonful. Now, what are we giving with these doses? I once took the trouble to make the calculations, and found that a tablespoonful, equalling five drachms, contained: (1) of paregoric about ♏xxxv., which by another similar calculation I found was equivalent to gr. $\frac{1}{8}$ of opium; (2) of wine of antimony, ♏xviii., which yet another calculation showed to contain gr. $\frac{1}{14}$ of tartar emetic. The other ingredients, being of no consequence medicinally, need not be estimated. Now these calculations, which are indispensable if we wish to know how much opium and how much tartar emetic our patient is getting with his repeated spoonfuls of brown mixture, are quite troublesome to make, and the results are difficult to remember. A similar task has to be performed in magistral prescriptions, when, instead of making out the value of the single dose of a complex and voluminous preparation, we proceed from the single dose with a view to formulating a mixture or pilular mass which shall be taken by repeated single doses, and last a stated time.

To illustrate the simplicity of metric formulas, on the other hand, let us take the *liquor hydrargyri bichloridi*, or *liqueur de Van Swieten* of the French codex. This solution contains: of the bichloride of mercury 1 gramme, or part, or unit of weight; of rectified spirit, 100 grammes, or parts; of water, 900 grammes, or parts. The liquid consequently contains one thousandth of its weight of the bichloride, and 5 grammes, the approximated value of a teaspoonful, contain 5 milligrammes of the drug.

Fowler's solution of arsenite of potassium, as formulated in the French codex, contains: of arsenious acid, 5 grammes; of carbonate of potassium, 5 grammes; of distilled water, 500 grammes; of alcohol, 15 grammes. After certain manipulations, comprising boiling, water is added to replace that lost, so that the whole weighs exactly 500 grammes, and thus contains one hundredth of its weight of arsenious acid. Of course the value in arsenious acid of any quantity by weight of the liquid is easily recognized.

One more example: let us take a magistral formula, the *sirop de Gibert*, or syrup of iodurated biniodide of mercury, a most valuable preparation. It contains: of the biniodide, 1 gramme; of iodide of potassium, 50 grammes; of water, 50 grammes, to which are added 2400

grammes of syrup of a certain specific gravity. The ratios involved are very simple, and we see at a glance, and remember with almost equal facility, that a tablespoon, holding 25 grammes of syrup, must contain one centigramme of the biniodide and 50 centigrammes of iodide of potassium. If now we should wish to formulate an analogous eight-ounce mixture we should find the necessary computations very tedious and difficult to perform accurately when in a hurry.

Our present system, then, is exceedingly complicated and difficult to manage in prescribing, in consequence of the absence of decimal divisions, and in consequence of the constant *changes of denomination* which result from processes of multiplication and division. One result, I believe, of this complexity of our system of weights and measures is the inordinate use in this country of *officinal*, in preference to *magistral*, or extemporaneous preparations. Many of our officinal remedies, to which we so largely resort, are complicated preparations, which have been elaborated at leisure by skilful and ingenious pharmacists, or by physicians of by-gone days, anterior to the time of rational therapeutics. These formulas, often embodying in one preparation such a number of active ingredients as to render it difficult or impossible to discriminate their effects upon the patient, are for the most part relics of an irrational and obsolete polypharmacy. Other analogous formulas are to be found scattered through text-books and treatises of theory and practice under the heading of "treatment." By many young physicians and students such formulas are copied out in memorandum-books, or learned by heart, and are used in a routine way, as if they represented simple drugs. Of course, when such habits of routine practice prevail, any advance in rational therapeutics is almost out of the question, and that self-education which should constantly be the chief object of our medication, after the benefit which we hope to confer upon the patient, is rendered difficult or impossible. Judging from the almost entire absence of such therapeutical formulas in text-books and treatises devoted to the instruction of French and German students and physicians, little or no assistance of this kind seems to be needed by them. If, now, magistral preparations were more extensively used, as would undoubtedly be the case if our system of weights and measures were easier to manage, then comparatively simple formulas would be readily improvised to meet the varying exigencies of individual cases, the tendency to polypharmacy would be diminished, the study and practice of rational therapeutics would be facilitated, and last, not least, the extensive use of patent medicines by physicians, which is the opprobrium of the medical profession of this country, would be lessened.

The second innovation comprised in the adoption by physicians of the system used in Continental Europe is the use of *gravimetric methods only*, for liquids as well as for solids. This is not an indispensable feat-

ure of the metric system, since the latter affords volumetric measures, decimally divided and having definite relations to the metric weights, which might with advantage be substituted for our present incongruous fluid measures. This innovation is, moreover, one which threatens to offer considerable difficulties and to meet with great opposition among physicians. If, then, it should appear likely to prove impracticable to bring about this change, we might for the present content ourselves with the simple substitution of metric weights *and measures* for those now in use.

But there can be little doubt that we shall in time generally recognize the intrinsic advantages of the gravimetric measurement of liquids, as well as the extrinsic advantage of conformity in this matter with European practice; and it may perhaps prove easier, if we are going to undertake any change in our system of weighing and measuring, to make it completely, once and for all.

The present state of the matter as regards the handling of liquids is as follows: while in England all solids are prescribed and dispensed by weight and all liquids by measurement, and while in all other countries solids and liquids alike are weighed, among us not only solids but also certain liquids, namely, acids, oils, honey, and chloroform, are ordered and dispensed by weight, other liquids being ordered by measurement.

What, now, will be the advantages and what the obstacles to the introduction of the gravimetric method for both solids and liquids? The first advantage to be looked for is conformity with the practice of all the nations which have adopted the metric system. The second and more important advantage lies in the greater accuracy in dispensing attainable by means of the gravimetric manipulation of liquids. Professor Maisch, after alluding to the frequent inaccuracy of the graduated measures now in use, to the difficulty of correctly reading the level of the liquid against the engraved scale, and to the additional uncertainties due to volatility and adhesion, says: "The greater convenience and correctness of weights have long since been recognized in the wholesale trade. Our Pharmacopœia even recognizes the correctness of this fact by having changed, in the last two revisions, all measures of the liquid acids, of chloroform, olive oil, and honey into weights. If these liquids are more conveniently and correctly handled by weight, why not likewise glycerine, syrups, tinctures, ethers, etc.?" He adds: "The dispensing of liquids by weight offers for all the reasons advanced by far greater accuracy than could be attained by measures."

Leaving, however, the facilitation of exact dispensing, which is a subject on which I am not qualified to express an opinion, I think there can be little doubt about the greater accuracy of prescriptions in which the quantities of all the ingredients, liquid as well as solid, are expressed by weight. A solid dissolved is a liquid, whose density, and conse-

quently whose exact bulk, we cannot readily ascertain. As Professor Maisch observes, solids dissolved in liquids add to the bulk of the latter. Moreover, certain liquids when mixed together contract, as is the case with alcohol or concentrated acids mixed with water. I think also that it is easier to recognize the ratio of a dissolved solid ingredient to its vehicle (whether the latter be water, syrup, or alcohol) when both are weighed than when the solids are weighed and the liquids measured, as in the *mistura glycyrrhizæ composita*, which was taken as an instance of our present way of dispensing.

The great difficulty which stands in the way of this innovation is that we have all contracted the habit of estimating liquids by measurement alone, and of remembering doses by bulk. We know only for distilled water the exact equivalence of our fluid measures in grammes; and unless we ascertain by experiment, or by calculation based on the knowledge of the specific gravity, the value in grammes of our present fluid measures (drachms and ounces) for every liquid, or at least for certain types of liquids, we shall have to treat all liquids by weight on the erroneous assumption that they have the same specific gravity as water.

The former solution of the difficulty is of course the correct one, and in due time we shall get to know all doses by weight, as we now know them by bulk. In furtherance of this end it is desirable that tables be constructed as soon as possible giving the value in grammes of the f℥ or f℈ of certain important liquid drugs (for example, *extract. ergot. fluid.*), as well as of certain types or categories of liquids, such as aqueous, alcoholic, and syrupy liquids. Future editions of the Dispensatory ought to give the corresponding values of every liquid by measurement and by weight in grammes.

But if, at present, instead of using metric measures of capacity for liquids, as has been proposed and is certainly feasible, we were to consider the fluid drachm of all liquids as equivalent to 3.69 grammes, this being the weight of one fluid drachm of distilled water, what would be the possible extent of the error involved? The inaccuracy of such a way of proceeding has been made a great "bugbear" by the opponents of the metric system. Lists of liquids of different densities have been gotten up, headed by ether, whose specific gravity is 0.728, and ending with chloroform, whose specific gravity is 1.490, water at 1.000, and syrups, from 1.310 to 1.320, coming between. The difference between the extreme specific gravities is as one to two, and a corresponding degree of inaccuracy in prescriptions has been predicted.

As a fact, however, neither ether nor chloroform is ever given in bulk or pure, unless it be by drops. Tinctures differ but slightly in specific gravity from water; aqueous solutions vary from 1.000 upwards, syrups at 1.320 representing the maximum specific gravity. The heaviest fluids, namely, syrups, rarely contain powerful drugs, and are hardly

ever given pure, being chiefly used for the purpose of imparting flavor. If, now, we should treat syrups as if of specific gravity 1.000, and assume the fluid drachm to weigh 3.69 grammes, the inaccuracy, as regards the amount of syrup alone, amounts to about twenty-five per cent. ; but in mixtures, into which syrups rarely enter in greater amount than one fifth of the whole, the inaccuracy would amount to four or five per cent. only of the whole mixture.

Now this inaccuracy, which could easily be reduced to a much more insignificant error, if not altogether annulled, by making a slight allowance for liquids heavier than water, has been held up as an insuperable objection to the substitution of the gravimetric method for the volumetric measurement of liquids. It seems to me, however, that those who urge this objection are claiming for their therapeutical operations a degree of accuracy which is rarely or never realized in practice.

It has been shown most clearly by Professor Maisch and by other authorities that the system actually in use involves a considerable degree of inaccuracy in the *prescription* and in the *dispensing* of medicines. There is a further and still greater margin of inaccuracy in the *administration* of medicines, owing to the false estimates in vogue with regard to the value of spoonfuls and drops, in which forms our drugs finally reach the patient.

A tablespoon is commonly supposed to contain half an ounce ; it really contains nearly six drachms, almost half as much again. A teaspoon, estimated to hold a fluid drachm, or sixty minims, really holds eighty minims, or one third as much again. A drop, supposed to be about equal to a minim, has values varying between a quarter of a minim and one minim and a quarter, the variation being as one to five ! The number of drops to a fluid drachm is with some fluids as low as forty-four, and with others as high as two hundred and seventy-six, if counted from a minim measure ; if counted from a bottle, on the other hand, some liquids give only forty-five drops to a fluid drachm, while others give as many as one hundred and eighty. For the same liquid the variation is often as two to three, according as the drops are counted from a bottle or from a minim measure. Thus a drachm of *tinctura opii* gives one hundred and forty-seven drops from a bottle and one hundred and six drops from a minim measure ; while a drachm of *tinctura ferri chloridi* gives one hundred and six drops from a bottle and one hundred and fifty-one drops from a minim measure. Yet, notwithstanding the great inaccuracy of this mode of measurement, drops are everywhere used in the prescription of the most concentrated and powerful liquid remedies, — such as, among others, tinct. digit., tinct. bellad., tinct. veratri viridis, tinct. aconiti radicis, acid. hydrocyan. dilut., liquor potassii arsenitis, etc. The danger of such grossly inaccurate measurements is obviated by the simple expedient, universally adopted, of giving in

every case small initial doses, which are gradually increased till the desired effect is attained, the final maximum dose in each case depending upon the quality of the drug and the susceptibility of the patient.

Thus we see that numerous causes of error beset our therapeutical operations in each of the necessary steps, as follows: (1.) *In prescriptions*, in consequence of the miscalculation of bulk when solids by weight and liquids by measurement are mixed. (2.) In *dispensing*, through the inaccuracy of graduates, the difficulty of reading correctly, volatility, adhesion, etc. (3.) In *administration*, in consequence of the prevailing erroneous estimates of spoonfuls and drops. I therefore venture to assert that the margin of inaccuracy is so great as to render insignificant a possible error of five per cent., due to the variations of specific gravity.

I believe, then, that the inaccuracy involved in neglecting, *for the present*, the differences of specific gravity of the various liquids would be more than compensated by the increase of accuracy which would accrue (after correction of our false estimates of the value of spoonfuls) from the substitution of the gravimetric handling of liquids for the mixed system, partly volumetric and partly gravimetric, now in use.

For all the reasons advanced I believe that the adoption by the medical profession of the metric system, as used in France, in Germany, and in many other countries, would be a most desirable consummation, and that it is expedient for us as physicians to make every effort to bring about this change.

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