MEDICAL PRACTICE

*Contemporary Themes***Simplifying infusion calculations**

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Continuous intravenous or subcutaneous infusion of drugs is increasingly common in many specialties. This increase reflects a better understanding of drug pharmacokinetics and a greater availability of infusion controllers and syringe pumps. Although local limitations on many nurses prevent them from administering drugs intravenously by "bolus" injections, they are allowed to control infusions. The use of infusions has induced errors resulting from their arithmetical complexity, which has even stimulated the writing of computer programs.

Many factors contribute to the complexity and we think that they have three main origins. The first is the different requirements of the medical and nursing staff concerned in the administration of the infusion. Medical staff wish to refer to the dose of drug per kilogram of body weight per unit of time. Only by using this standard can effect be related to dose and similar drug regimens compared. This value is, however, lost from sight by the need of the nursing staff to have a prescription based on the volume flow rate of the infusion, as this is what they actually control.

Secondly, the relation between the drug dosage rate and the volume is obfuscated by a bewildering array of expressions of concentration—percentages (vol/vol or wt/vol), parts per thousand, parts per mille (‰), mass or moles per 100 ml, per litre, or per ml. When a solution for infusion is made up on the ward probably the concentration will be expressed by describing the method of preparation—for example, "0.15 mg of fentanyl in 30 ml of saline." Apart from the ambiguity (was the solution made up to or with 30 ml saline?), a knowledge of the concentration of the original drug solution and a degree of arithmetic agility are required to determine the nature and strength of the infused solution and hence the dose being given to the patient. Manufacturers often suggest a suitable

dilution method without stating the concentration obtained, or suggest an infusion rate without giving the drug dose rate. In such obscurities lies a potential source of serious error.

Thirdly, infusions perforce require the intake of liquid which may contribute appreciably to the patient's total intake, and this is especially true in smaller patients and when several infusions are given simultaneously.

Although no single system can be universally applicable, it is desirable to have uniformity of expression of all the values required to prescribe an infusion. Thus we need (a) a unit of time (minute/hour/day) and (b) a unit of volume (ml/100 ml/litre).

Preferred units

We prefer the hour for most purposes, and our reasons are threefold. (a) Most intensive care units chart hourly intake and output, calculations of liquid intake (particularly in paediatrics) being made and the liquids given on an hourly basis; (b) the increasingly used syringe pumps are scaled in millilitres per hour; and (c) with an infusion set giving 60 drops per ml the number of drops per minute equals the number of millilitres per hour.

The minute may be more appropriate in an emergency case when frequent changes are necessary, but otherwise the above arguments remain true.

As the unit of volume for both concentration and flow rate the millilitre is the obvious choice, being generally used for liquid balance calculations. When concentrations of drug solutions are expressed as amount of drug per ml and infusion rates are given in ml per hour drug dosage rates in amount per hour are calculable on inspection.

For most drugs infusion rates in the micrograms per kg per hour range are used, although doses in other orders of magnitude are sometimes encountered—for example, prostacyclin at 900 ng/kg/h, and mannitol at 2g/kg/h.

Aids to computation

We have designed two aids to computation of infusions. In the Sheffield Children's Hospital an infused drug dose chart has been introduced (fig 1). This adheres to the time scale of the main record sheet, making it easy to see the relation of dosage and effect. It guides the prescriber through the

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calculations to obtain the dose per kg per hour. A space is delineated to show the dose resulting from an infusion of 1 ml per hour. Space is also available for noting the normal range of dose rates.

To help in the repeated calculation of dose rates we have devised a calculator (fig 2) in the form of a circular slide rule. This consists of a base on which revolve three largely translucent discs. These allow for the following ranges: (a) amount of drug in solution—100 µg-1000 mg; (b) volume in which diluted—1 ml-1000 ml; (c) patient's body weight—1 kg-100 kg; (d) amount of drug per hour—10 ng-1000 mg; (e) amount of drug per kg per hour—100 pg-1000 mg.

FIG 1—Sheffield Children's Hospital infused drug dose chart.

FIG 2—Infusion dosage calculator.

The calculator may be used in three ways.

Method 1 requires a knowledge of the following four measurements, which are selected in order: (a) patient's body weight; (b) amount of drug in solution; (c) volume of solution; (d) infusion rate in ml per hour. Drug dose per hour and drug dose per kg per hour may then be read off direct. A separate pointer is provided for those who prefer to work with minutes as the unit of time for the drug dose rate.

Method 2—When the volume available for infusion is limited—for example, because the remainder of the liquid intake is committed to electrolytes or energy providing compounds—the calculator may be used to determine a suitable concentration of the drug for infusion. To do this the following are selected: (a) patient's body weight; (b) rough estimate of drug dose rate required (amount per kg per hour); (c) infusion rate available. The calculator then shows the required drug concentration and presents a choice of amounts and volumes to produce this concentration.

Method 3—Economical use of drugs is facilitated by using the second method and also considering the probable duration of the infusion. From these are obtained the likely volume to be used, and so the preparation of excessive volumes may be avoided.

Discussion

Using the slide rule simplifies the repetitive calculation of the dose rate of drugs administered by infusion. This simplification will encourage comparison of dose regimens and hopefully reduce the possibility of error. It facilitates the incorporation of the volume of drug infusions in the total liquid calculations and encourages economy in dispensing of solutions.

We wish to take the introduction of the calculator as an

opportunity to recommend a standard approach to the description and prescribing of drugs for infusion. All drugs should be presented in the form of mass per unit volume only, and percentages, fractions, and proportions should be discontinued. If abbreviation is required then the % or pro mille, used in some countries, is the equivalent of the most commonly used milligrammes per millilitre. We propose that (a) infusion concentrations should be expressed as amount per millilitre; (b) infusion rates should be expressed in millilitres per hour; and (c) drug infusion regimens should be described by the amount per kg per hour—for example, 10 µg/kg/h, or 1.5 mmol/kg/h, or 2 IU/kg/h.

The calculator is produced by Janssen Pharmaceutical Ltd as a service to medicine and became available from October 1984.

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Is playing the violin likely to cause or aggravate cervical spondylosis?

The general answer is that it could if performed injudiciously but need not with care as to posture. Many beginners hold their instrument with vice like force between chin and shoulder in an effort to maintain the elevation of the violin and leave both arms free for their different functions. This habit may never be lost but it is counterproductive. It is possible with combinations of chin rest and shoulder pad supplementing the thickness of the violin body to occupy the whole depth between jaw and clavicle so that a mere touch with the left hand on the neck of the instrument is all that is needed to maintain contact and correct elevation. Thus no awkward neck position or noticeable tension is needed and cervical spondylosis would not become troublesome. —JOHN A MATHEWS, consultant physician (rheumatology), London.

Correction

ABC of Poisoning: Cardiac drugs

An error occurred in this paper by Dr John Henry and Dr Glyn Volans (20 October 1984, p 1062). In the section on specific treatment, under β adrenoceptor blocking drugs, an isoprenaline infusion was wrongly specified. This third sentence should have read: "The symptoms can, however, also be reversed by high doses of β adrenoceptor agonists such as isoprenaline by infusion (10-100 µg/min) or prenalterol."