Medical mathematics: dosing with precision

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Categories : Clinical, RVNs

Date : November 23, 2016

ABSTRACT

Medical mathematics is required for every medication and replacement fluid administered to patients, and the ability to perform calculations with precision is a responsibility of every veterinary nurse.

From simple medication calculations to IV fluid additives and potentially complicated constant rate infusions, understanding maths is a large part of working in hospital. VNs must be comfortable not only performing these calculations, but also in double-checking colleagues to ensure patient safety at all times.

This article serves as an introduction to basic medical mathematics, covering milligram to millilitre calculations, percentage calculations, adding medications to IV fluids and dextrose calculations.

Understanding drug calculations, fluid additives and dextrose solutions makes VNs valuable members of the medical team, ensuring quality care is delivered to patients.

Figure 1. Metronidazole showing the drug concentration as 5mg/ml.

Medications are measured both in weight and volume, and both parts are needed to determine the concentration of the drug.

For example, metronidazole is labelled as 5mg/ml (Papich, 2007). This means each millilitre (volume) of metronidazole contains 5mg (weight) of the drug.

This drug concentration is always listed on the packaging (**Figure 1**).

VNs will be given the drug dose (weight) and will need to calculate the appropriate volume to be administered to the patient.

This is a simple calculation defined as drug dose/drug concentration.

- Example – if the order is to administer 47mg of metronidazole to a dog (the drug dose) and the drug concentration is 5mg/ml, the nurse performs the calculation:

47mg/5mg per ml = 9.4ml drawn up and administered to the patient

Often, the order will be to administer milligrams per kilogram of bodyweight to a patient.

In this case, first multiply the dose by the patient’s weight, then proceed to divide that dose by the drug concentration.

- Example – the order is to administer 0.3mg/kg of metoclopramide (5mg/ml; Papich, 2007) to a 13kg dog:

0.3mg per kg x 13kg = 3.9mg (drug dose)

3.9mg (dose)/5mg per ml (concentration) = 0.78ml

- Example – administer 5mg/kg of ketamine (100mg/ml; Papich, 2007) to a 6kg cat:

5mg per kg x 6kg = 30mg (drug dose)

30mg / 100mg per ml = 0.3ml administered to the cat

Some drugs are listed as a per cent concentration. For example, the concentration of lidocaine is 2%.

To calculate the dosage, the mg/ml concentration must be determined. To determine the mg/ml of lidocaine, move the decimal one place to the right – so 2% = 20mg/ml.

- Example – administer 2mg/kg of lidocaine (2%; Papich, 2007) to a 35kg dog:

2% = 20mg/ml (concentration)

2mg per kg x 35kg = 70mg (dose)

70mg/20 mg per ml = 3.5ml

- Example – administer 4mg/kg of furosemide (5%; Papich, 2007) to a 4.5kg cat:

5% = 50mg/ml (concentration)

4mg per kg x 4.5kg = 18mg (dose)

18mg/50mg per ml = 0.36ml

Adding medications to IV fluids

This is another common calculation for VNs.

Potassium chloride (KCl), for example, is a common additive and the calculation is again dose/concentration.

- Example – an order reads to add 20mEq/L of KCl (2mEq/ml) to the IV fluids. If the litre of fluids is new, 20mEq is the dose and 2mEq/ml is the concentration:

20mEq/2mEq per ml = 10ml added to the litre

- Example – the order reads to add 15mEq/L of KCl (2mEq/ml) to a litre of fluids:

15mEq/2mEq per ml = 7.5ml added to the litre

Many times, the order to add medications comes after the IV fluids have been running. This calculation requires an extra step.

- Example – the order is to add 20mEq/L of KCl (2mEq/ml) to the fluids. There is 600ml remaining in the litre:

20mEq/2mEq per ml = 10ml (litre dose)

600ml left/1,000ml (litre) = 0.6

10ml x 0.6 = 6ml of KCl added to 600ml to make 20mEq/L

The litre of fluids must be labelled indicating the drug and dosage added. To avoid confusion, the label should read the concentration of drug per full litre, which, in this case, is 20mEq/L.

Also label the date, time and initials of the nurse who added the medication (**Figure 2**).

- Example – the order reads to add 30mEq/L of KCl (2mEq/ml) to the fluids, with 450ml remaining in the litre:

30mEq/2mEq per ml = 15ml (litre dose)

450ml remaining/1,000ml (litre) = 0.45

15ml (full litre dose)/ 0.45 = 6.75ml of KCl added to 450ml to make 30mEq/L

Adding dextrose

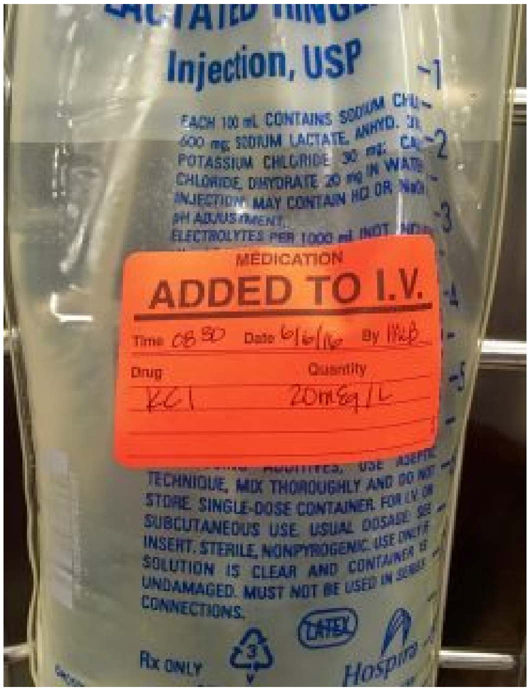

Figure 2. Appropriate labelling of IV fluids with medication added, showing the drug, concentration, date, time and initials of nurse.

Dextrose is commonly added to IV fluids for patients requiring blood glucose support. This order is given as creating a percentage solution. For example, make the IV fluids at 2.5% dextrose.

The equation to calculate how much dextrose to add to make these solutions is:

Amount of fluids x % desired (ordered)
_% of dextrose adding (concentration)

- Example – make one litre of fluids 2.5% dextrose (ordered) using 50% dextrose (concentration):

1,000ml x 2.5 (ordered)]
50 (concentration)

2500 / 50 = 50ml of 50% dextrose needed

Because the calculation used a final volume of 1,000ml, withdraw 50ml of fluids prior to adding 50ml of 50 per cent dextrose. This fluid bag must be labelled as 2.5 per cent dextrose along with the date, time and initials of the nurse who calculated the solution.

- Example – an order reads to make 700ml of fluids 5 per cent dextrose (ordered) using 50 per cent dextrose (concentration):

700ml x 5 (ordered)
50 (concentration)

3,500 / 50 = 70ml of 50% dextrose needed

Because the calculation used a final volume of 700ml, withdraw 70ml of fluids from the bag prior to adding the 70ml of 50% dextrose.

In a hypoglycaemic crisis, higher percentages of dextrose may be ordered, such as 25% (Silverstein, 2009); however the calculation is the same.

If a hypoglycaemic cat experiences a seizure due to the hypoglycaemia, the vet may order the VN to administer 6ml of 25% dextrose (ordered), yet the hospital stocks 50% (concentration):

[6ml x 25 (ordered)]
50 (concentration)

150 / 50 = 3ml of 50% dextrose

In this case, 6ml is the total volume and 3ml is the volume of dextrose required:

6ml – 3ml = 3ml of 0.9% NaCl needed

The nurse mixes 3ml of 50% dextrose and 3ml of 0.9% NaCl to achieve a 25 per cent dextrose solution to administer to the patient.

Fluid rates

When drugs are added to IV fluids, it is advantageous for VNs to understand how much drug is administered based on the fluid rate per hour, and be able to calculate the new dose being delivered if the fluid rate changes.

To determine this, the milligram per millilitre concentration of the IV fluids must be calculated, then examined with the fluid rate and patient weight.

- Example – a 21kg dog is on a fluid rate of 65ml/hr and has 13.5mg/L of metoclopramide added to the fluids.

To determine the dose of metoclopramide:

13.5mg per litre/1,000ml = 0.0135mg of metoclopramide per ml

65ml per hour delivered x 0.0135mg per ml = 0.88mg per hour

0.88mg per hour/21kg = 0.04mg of metoclopramide per kg per hour delivered to the dog

The vet then orders a fluid rate change up to 100ml/hr, so how does this change the dose of drug delivered to the dog?

0.0135mg of metoclopramide per ml

100ml per hour delivered x 0.0135mg per ml = 1.35mg per hour

1.35mg per hour/21kg = 0.06mg of metoclopramide per kg per hour delivered to the dog

This new delivery rate can be checked against drug safety margins, or therapeutic goals, and adjusted as needed.

- Example – a 4kg cat presents to the hospital with hypokalaemia and is placed on a fluid rate of 12ml/hr with 40mEq/L of KCl added to the fluids.

To determine the dose of KCl delivered to the patient:

40mEq per litre/1,000ml = 0.04mEq KCl per ml

12ml per hour delivered x 0.04mEq = 0.48mEq per hour

0.48mEq per hour/4kg = 0.12mEq of KCl per kg per hour being delivered to the cat

The vet then orders the fluid rate to be increased to 20ml/hr. How does this change the dosage delivered to the cat?

0.04mEq KCl per ml

20ml per hour delivered x 0.04mEq per ml = 0.8mEq per hour

0.8mEq per hour/4kg = 0.2mEq KCl per kg per hour delivered to the cat

Again, this new rate of potassium chloride delivery can be checked against drug safety margins, or therapeutic goals, and adjusted as needed.

Conclusion

It is important VNs not only understand the maths and how to calculate drug doses, but are also familiar with common volumes of medications commonly administered.

This knowledge can act as a backup "sanity check" when drawing up drug doses.

If, for example, a decimal is inadvertently moved in a calculation leading to a drug volume of 17ml to be administered to a small cat, the nurse should pause, knowing few times exist when a small patient needs such a large volume of any medication.

At this point, the nurse should recalculate the drug.

Always, if unsure about a calculation, ask for another nurse or vet to check the maths.

If you are unfamiliar with the drug, ask before administering to ensure volume is correct.

Mistakes can be avoided if veterinary teams work together and double-check each other.

References

- Papich MG (2007). *Saunders Handbook of Veterinary Drugs* (2nd edn), Elsevier Saunders, St Louis.
- Silverstein DC and Hopper K (2009). *Small Animal Critical Care Medicine*, Saunders Elsevier, St Louis.