

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <https://orca.cardiff.ac.uk/id/eprint/189999/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Pritchard, Anthony 2026. How to calculate the dosage and infusion rate for administration of intravenous medicines. *Nursing Standard* 10.7748/ns.2026.e12772

Publishers page: <https://doi.org/10.7748/ns.2026.e12772>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See <http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



How to undertake intravenous (IV) drug calculations

Rationale and key points

Administration of intravenous (IV) medicines, fluids and blood products to adults and children and the dosage and rate calculations required is a fundamental nursing proficiency. Nurses undertaking IV drug calculations must have the knowledge and skills required to do so safely and must work within their level of competence.

- Ensure you are familiar with and use the correct medicines calculation for the type of infusion being administered, such as a gravity giving set or an electronic infusion pump.
- Be familiar with and competent in the use of any electronic systems or apps in the clinical area that are designed to help with medicine calculations.
- Always follow the local medicines policy, and it is advisable to use a second checker who calculates independently even if the policy does not require this.

Reflective activity

'How to' articles can help to update your practice and ensure it remains evidence based. Apply this article to your practice. Reflect on and write a short account of:

- How this article might improve your ability to safely undertake IV drug calculations.
- How you could use this information to educate nursing students or colleagues in the competent calculations of IV medicines.

Keywords: To be drawn from the Nursing Standard conductor

To ensure patient safety and the maximum patient benefit from prescribed IV medicines, fluids and blood products, medicine dosage and rate calculations are required. It is essential that nurses (and other healthcare professionals) undertaking these calculations can do so accurately. Nurses must ensure that they have the requisite skills and knowledge to undertake this activity and recognise when there are limitations in their level of competence. Errors in IV dose and rate calculations are a significant factor in medication errors. As medicines administered via the IV route enter the blood stream directly, they cannot be retrieved, and errors can cause significant harm to patients. Causative

factors in IV dose and rate calculation errors include unfamiliarity with basic mathematical principles, conceptual errors and unfamiliarity with equipment such as giving sets and infusion pumps.

Preparation and equipment

Due to the complexity associated with preparing and administering IV medicines and fluids, and as with all medicines calculations, this activity should be undertaken in a quiet environment with interruptions minimised (Vital et al 2026, Johnson et al. 2017). Nurses must also ensure that they are conversant with local medicines policies such as when two-person checking is required and ensure that this occurs.

Although no specific equipment is required to undertake calculations for the safe administration of IV medicines and fluids, because calculations are often multi-stage, having a pen and paper and an electronic calculator available may improve accuracy. Nurses must also have knowledge and understanding of the formulae to be used (see box....) and be able to enter numerical information in the correct sequence when using an electronic calculator or working out calculations long hand. However, whilst they are useful, it is important to remember that calculators cannot prevent calculation and conceptual errors occurring (Fletcher-Wilmes et al. 2018).

Be familiar with and competent in the use of any electronic systems or apps in the clinical area that are designed to help with medicine calculations. Whatever device you use to calculate medicine dosage will only do so accurately if you enter the correct figures (Pritchard 2026).

To ensure patient safety and that IV medication and fluids have maximum benefit, nurses must recognise when they are having difficulty undertaking calculations and ensure that they access support and education to address any deficits in competence (NMC 2018). Where infusion pumps, syringe drivers and SMART pumps are used, nurses must have received training in their use and be competent in programming them.

Procedure

1. Perform hand decontamination in accordance with local policy.
2. Obtain the patient's prescription record, this can be paper based or more frequently electronic. Ensure that identification checks are made as per local policy.
3. Identify which IV fluid or medicine is due to be administered.
4. Perform checks to ensure that the fluid/medication packaging is intact and in-date.

5. Obtain the appropriate infusion set and check that the packaging is intact and in-date. Check the manufacturer information on the infusion set packaging to determine number of drops per mL (for IV gravity infusions).
6. Where an electronic infusion pump is **not** used and the intravenous infusion is administered via an IV gravity giving set, you must calculate the number of drops per minute required to give an IV infusion over the time prescribed. To do this see box 1.

Box 1. Calculating the drops per minute for an IV gravity giving set

Calculate the number of millilitres (mL) required per hour. This is achieved by dividing the volume of the infusion by the number of hours. For example, 1000mL to be given over 8 hours would be $1000 \text{ (volume to be given)} \div 8 \text{ (duration of infusion)} = 125 \text{ mL per hour}$

Look for the number of drops per mL for the giving set. This is printed on the packaging of the giving set by the manufacturer. There are different types of giving set available including giving sets for crystalloids, blood products and specialised giving sets with in-line burettes. Usually, a giving set for a crystalloid solution is 20 drops = 1mL

The number of mL per hour is multiplied by the number of drops per mL to give drops per hour. For example, $125 \text{ mL/hours} \times 20 = 2500 \text{ drops per hour}$.

Divide the number of drops per hour by 60 to give the drops per minute. For example, $2500 \div 60 = 41.66$ which is rounded up to 42.

Adjust the roller clamp on the giving set to administer 42 drops per minute in this example.

7. If the infusion is to be given via an electronic pump, examine the prescription record for information of the volume of fluid to be administered and the time over which it is to be given.
8. Perform the calculation to work out the flow rate to be programmed. To do this see box 2.

Box 2. Calculating the flow rate per hour for an electronic pump

Volume to be infused (mL)

_____ = Flow rate (mL/hour)

Number of hours

9. To calculate the rate to be programmed into the electronic pump for medicines prescribed as infusions in microgrammes per kilogramme per minute, make sure you know the patient's weight in kg and use the following steps as used in this example in box 3:

Box 3. Calculating the rate for medicines prescribed as infusions in microgrammes per kilogramme per minute

Mr Kim Lee has been prescribed noradrenaline 4mg in 50mL to be given at a starting dose of 0.1 microgrammes/kg/minute. He weighs 70 kg.

Work out the number of microgrammes per mL. This will need an SI unit conversion.

SI unit conversions

SI unit conversions

1g = 1000 milligrams

1 milligram = 1000 microgrammes

1 microgram = 1000 nanograms

4 mg x 1000 = 4000 microgrammes.

4000 (microgrammes) ÷ 50 (volume in mL) = 80 microgrammes per mL.

Work out the number of microgrammes needed per minute.

$$70 \text{ (kg)} \times 0.1 \text{ (microgrammes)} = 7 \text{ microgrammes per minute}$$

Work out the microgrammes needed per hour

$$7 \times 60 \text{ (minutes)} = 420 \text{ microgrammes per hour}$$

Work out the pump rate in mL/hour

Dose (in microgrammes per hour)	420	
_____	_____	= 5.25 mL/hour
Concentration of drug (microgrammes per mL)	80	

Therefore, a rate of 5.25 mL per hour will give a dose of 0.1 microgrammes/kg/min.

10. If a second check is required, the second checker should follow the steps above independently. Once this has been undertaken and the infusion rate agreed, connect the infusion set to the patient's IV access device.
11. Programme the infusion pump with the rate and commence the infusion.
12. For gravity infusion sets, the roller clamp will be adjusted until the desired drops per minute rate is achieved.
13. If there is any doubt about the accuracy of the calculations carried out, advice must be sought from the prescriber or pharmacist.
14. During the infusion, regular checks must be made on the rate to ensure it delivering correctly. This is particularly important with gravity infusion sets, because patient position and the height of the bag of fluid/blood above the site of IV access device can impact the rate of delivery.

Evidence base

Administration of intravenous medicines, fluids and blood products is a common activity undertaken by nurses and midwives, with a significant amount of time being spent on this activity (Walsby et al

2024). In the UK, the regulatory Nursing and Midwifery Council (NMC 2018a) requires that nurses (and midwives) are competent in administering IV medicines, fluids and blood products using a range of devices. As with the administration of oral medicines, it is vital that nurses can demonstrate their competence in undertaking the calculations required to perform this task safely (RCN and RPS 2019, NMC 2018, NICE 2017). Inaccurate dosage and rate calculations are a major factor in reported medication errors (Kuitunen et al 2024, WHO 2023, Mulac 2022, Cavell and Mandaliya 2021, Sutherland et al. 2020). Most employers (NHS and private sector) require nurses who are administering IV medicines to undergo further training and assessment, a key component of this being calculating dose and rate.

Nurses are accountable for their practice, and they need to ensure that their knowledge and skills are up to date and that they recognise, reflect on and seek support to address any limitations in their professional practice (NMC 2018a).

Risks associated with IV dose calculation errors

Administration of IV medicines by nurses using a range of devices is a fundamental proficiency required by the NMC (NMC 2018a, NMC 2023). Nurses must be able to perform several stages accurately in order to ensure patient safety when preparing, administering and monitoring a medicine, infusion or blood product given by the IV route. Administration of medicines and fluids intravenously has several advantages over the oral route. When the medicine or fluid enters the patient's blood stream directly it often has a faster onset of action as therapeutic levels are more rapidly attained and avoids issues which can affect absorption via the gastrointestinal tract such as gastroparesis (Hill et al 2022). However, because of the rapid onset of action and that there is no way to retrieve the medicine or fluid given by the IV route, there is an increased risk of adverse effects if errors in calculation of dosage or rate of administration are made (Rajakumar et al 2025).

Number and type of errors related to IV medicine administration.

Drug dosage calculation errors are a major source of patient harm worldwide (WHO 2023). In the UK, it was found that approximately 237 million medication errors occurred annually in England (Elliott et al 2021) with most of these occurring at the administration stage. For IV medications, it has been estimated that errors occur with up to 10.1% of all administrations (Sutherland et al 2020). Wrong dose and wrong rate errors were reported to be the most frequent type of error involving intravenous drugs in a large-scale review of medication errors in Norway (Mulac et al 2021). In the UK, Cavill and Mandaliya (2021) reported that 81.8% of medication errors involving intravenously administered medicines were due to wrong dose and 9.3% were due to wrong rate. In systematic reviews undertaken

by Sutherland et al (2020) and Rajakumar et al (2025) wrong rate errors accounted for approximately 57.9% of errors, and wrong dose errors were also widely reported. Worryingly, Tuthill and Tse (2021) and Mulac et al (2021) reported that errors in calculating dose could result in 10 and 100-fold under or overdoses which can have a significant impact on patient safety.

Extensive research (Weeks 2013, 2015, Elonen 2021) Wennberg-Capellades et al 2022) has been undertaken to explore nurses and nursing students' competence in performing medication calculations in the UK and more widely. This research has highlighted that nurses and nursing students experience difficulties in calculating infusion rates and concentration over time and in contextualising their answers to real world situations. Wennberg-Capellades et al (2022) undertook a retrospective study examining 285 calculation test papers completed by nursing students in all three years of an undergraduate nursing programme. They found that students struggle with undertaking multistage calculations required for IV administration of medicines and fluids, including infusion rate and infusion time calculations.

Strategies to reduce IV medication calculation and rate of delivery errors

A time and motion study undertaken by MacDonald et al (2024), found that administration of IV antibiotics took approximately six times longer to prepare than the oral equivalent. They also found that whilst preparing the medicine for administration, nurses faced multiple interruptions. Vital et al (2026) evaluated the effect of interruptions in IV medication administration via smart pump in an ICU setting. Results showed that nurses were interrupted in 44 out of 100 activities involving programming intravenous smart pumps observed. Both Vital et al (2026) and MacDonald et al (2024) concluded that due to the point of care nature of administering IV medicines and fluids, limiting the number of interruptions not only reduces the time spent on performing this complex task, but also enhances patient safety through the potential reduction in calculation and programming errors.

Example one:

Mrs Anisha Patel has been prescribed 1000mL 0.9% saline to be given over 12 hours

Step 1: The number of mL per hour is calculated: $1000 \text{ (volume to be given)} \div 12 \text{ (duration of infusion)} = 83.33 \text{ (rounded to 83) mL per hour}$

Step 2: The nurse reads the information on the fluid giving set which states that 20 drops = 1mL

Step 3: The drops per hour are calculated: $83 \text{ (volume per hour)} \times 20 \text{ (drops per mL)} = 1660 \text{ drops per hour}$

Step 4: Calculate the drops per minute: $1660 \div 60 = 27.66 \text{ drops per minute}$. This is rounded to 28 drops per minute. The nurse adjusts the roller clamp on the giving set to give 28 drops per minute.

Example two:

Mr Dewi Jones requires a blood transfusion. He is prescribed a unit of packed red cells over four hours. The bag of packed red cells contains 284 mL of blood.

Step 1: The number of mL per hour is calculated: $284 \text{ mL} \div 4 = 71 \text{ mL per hour}$

Step 2: The nurse reads the information on the blood giving set which states that 15 drops = 1mL

Step 3: The drops per hour are calculated: $71 \times 15 = 1065 \text{ drops per hour}$

Step 4: Calculate the drops per minute: $1065 \div 60 = 17.75 \text{ drops per minute}$. This is rounded to 18 drops per minute. The nurse adjusts the roller clamp on the giving set to give 18 drops per minute.

In some settings (e.g. paediatrics and critical care), an infusion set with an in-line burette and micro drops is used. These sets allow for precise control over rate of administration (Joint Formulary Committee 2026).

Example three:

To work out infusion rates to set on syringe drivers, the nurse needs to undertake the following calculations:

$\text{Volume} \div \text{number of hours} = \text{rate}$

Mr David Smith is prescribed an infusion of amiodarone 1.2 g in 50mL to be administered over 24 hours.

$$50 \div 24 = 2.08$$

The rate 2.08 mL per hour is set on the syringe driver.

Example 4:

Nurses also need to be able to calculate the dose being given whilst an infusion is in progress - e.g. at shift handover.

The nurse checks the syringe label and prescription record and confirms that the syringe contains 8mg of adrenaline in 50mL and it is infusing at 5.4 mL/hour. The patient Mrs Patel weighs 80kg.

Step one: an SI unit conversion is calculated: $8 \times 1000 = 8000$ microgrammes in 50 mL

$$8000 \div 50 \text{ (volume in mL)} = 160 \text{ microgrammes per mL}$$

Step two: microgrammes per hour is calculated $5.4 \text{ mL (rate)} \times 160 = 864$

Step three: microgrammes per kg per minute is calculated $864 \text{ (microgrammes per hour)}$

$$\text{-----} = 0.18$$

$$80 \text{ (kg)} \times 60 \text{ (minutes)}$$

0.18 microgramme/kg/minute of adrenaline is being given.

References

- Cavell GF, Mandaliya D (2021) Magnitude of error: a review of wrong dose medication incidents reported to a UK hospital voluntary reporting system. *European Journal of Hospital Pharmacy*. 28, 5, 260-265. doi: 10.1136/ejhpharm-2019-001987
- Fletcher-Wilmes M, Branstetter-Hall JE, Felicilda-Reynaldo RFD (2018) Manual Dosage and Infusion Rate Calculations During Disasters: Review of a Problem-Solving Approach *MEDSURG Nursing*; Pitman 27 (4) 247-250.
- Johnson M, Sanchez P, Langdon R et al (2017) The impact of interruptions on medication errors in hospitals: an observational study of nurses. *Journal of Nursing Management*. 25, 7, 498-507. doi: 10.1111/jonm.12486
- Kuitunen S, Airakinen M, Holmstrom AR (2024) Evolution of Intravenous Medication Errors and Preventive Systemic Defences in Hospital Settings- A Narrative Review of Recent Evidence *Journal of Patient Safety* 20 (4) e29-e39
- MacDonald, C. Y, Lobban A., Rose, R. Stephen, L. Lynas, G. Aslam, A. McCormick, S. Brown A. (2024) 'Tabs versus Jabs' time and motion study involving experiential learning student pharmacists: how long to prepare intravenous versus oral antibiotics? *International Journal of Pharmacy Practice*, 2024, Vol. 32, suppl 2 ii38-ii39
- Mulac A, Taxis K, Hagesaether E et al (2021b) Severe and fatal medication errors in hospitals: findings from the Norwegian Incident Report System. *European Journal of Hospital Pharmacy*. 28, Supl 2, e56-e61. doi: 10.1136/ejhpharm-2020-002298
- British National Formulary (BNF)
- Joint Formulary Committee (2026) *British National Formulary*. No. 89. BMJ Group and the Royal Pharmaceutical Society of Great Britain, London.
- NHS Resolution (2022) Did You Know? Insights into Medication Errors. resolution.nhs.uk/wp-content/uploads/2022/03/Did-You-Know-High-Level-Medication-Errors.pdf (Last accessed: 9 December 2025.)
- Nursing and Midwifery Council (2018a) Standards of Proficiency for Registered Nurses. NMC, London.
- Nursing and Midwifery Council (2018b) The Code: Professional Standards of Practice and Behaviour for Nurses, Midwives and Nursing Associates. NMC, London.

Nursing and Midwifery Council (2023) Standards for Education and Training: Part 3: Standards for Pre-Registration Nursing Programmes.

www.nmc.org.uk/globalassets/sitedocuments/standards/2024/standards-for-pre-registration-nursing-programmes.pdf (Last accessed: 9 December 2025.)

Pritchard A (2026) How to undertake oral medicine dosage calculations. *Nursing Standard*. doi: 10.7748/ns.2026.e12636

Rajakumar S, Rajah R, Thanimalai S, Mokhtar F and Ramachandram D (2025) Intravenous Medication Administration Errors in Hospitalised Patients: An Updated Systematic Review *Journal of Evaluation in Clinical Practice* 30:e:70167 doi.org/10.1111/jep.70167

Royal Pharmaceutical Society, Royal College of Nursing (2019) Professional Guidance on the Administration of Medicines in Healthcare Settings.

www.rpharms.com/Portals/0/RPS%20document%20library/Open%20access/Professional%20standards/SSHM%20and%20Admin/Admin%20of%20Meds%20prof%20guidance.pdf (Last accessed: 9 December 2025.)

Sutherland A, Canobbio M, Clarke J, Randall M, Skelland T and Weston E (2020) Incidence and prevalence of intravenous medication errors in the UK: a systematic review *European Journal of Hospital Pharmacy* 27, 3-8 doi:10.1136/ejhpharm-2018-001624

Tse V and Tuthill D (2021) Incidence of paediatric 10-fold medication errors in Wales *Arc Dis Child*, 106 656-661

Vital CJ, Schroers G, Fortnam K, Eckel SF, Degnan D, Armistead LT and Giuliano KK (2026) Evaluation of Interruptions During IV Smart Pump Medication Administration in Intensive Care Units *Journal of Patient Safety* 22 (2) 115-120 DOI: 10.1097/PTS.0000000000001427

Walsby A, Williams S, Gammon J et al (2024) The reality of nursing time: how nurses spend their shifts. *British Journal of Nursing*. 33, 20, 968-974. doi: 10.12968/bjon.2024.0050

Weeks KW, Coben D, O'Neill D et al (2019) Developing and integrating nursing competence through authentic technology-enhanced clinical simulation education: pedagogies for reconceptualising the theory-practice gap. *Nurse Education in Practice*. 37, 29-38. doi: 10.1016/j.nepr.2019.04.010

Weeks KW, Sabin M, Pontin D et al (2013) Safety in numbers: an introduction to the nurse education in practice series. *Nurse Education in Practice*. 13, 2, e4-e10. doi: 10.1016/j.nepr.2012.06.006

Westbrook JL, Li L, Hooper TD et al (2017) Effectiveness of a 'Do not interrupt' bundled intervention to reduce interruptions during medication administration: a cluster randomised controlled feasibility study. *BMJ Quality and Safety*. 26, 9, 734-742. doi: 10.1136/bmjqs-2016-006123

World Health Organization (2023) Global Burden of Preventable Medication Related Harm: A Systematic Review. World Health Organization, Geneva.