METROLOGY for DRUG DELIVERY

REPORT:

COVID-19 Crisis & Emergency Practices - Infusion Pumps in ICU:

THE ROLE OF METROLOGY

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This report was produced as a deliverable outlined in the Exploitation Plan, covering a case study from the EMPIR Metrology for Drug Delivery (MeDD II) project. The three-year European project commenced on 1st June 2019 and focused on providing traceable measurements of volume, flow and pressure of existing drug delivery devices and mixing behaviour and occlusion phenomena in multi-infusion systems. For more details about this project, please visit www.drugmetrology.com

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Introduction

The unprecedented conditions that Public Health Institutions are experiencing due to COVID-19 pandemic crisis has forced Hospital Administrations to take measures outside the usual work practices in order to manage several challenges, including:

- reduction of exposure of health care staff to COVID-19
- preservation of personal protective equipment (PPE)
- management of shortages of equipment
- management of wastage of now-very-scarce critical medications needed for Covid19 care and other critical drugs or substances
- management of staff shortage and reorientation of staff to areas outside their usual area of expertise

The extraordinary measures taken by some hospitals include:

- to use the drug delivery devices outside the patients' room
- to use the drug delivery devices with associated clinical risks and lower accuracy
- to postpone the deadlines of maintenance and calibration of equipment with critical use

These practices might seem necessary to preserve the patient care. But they can lead to large dosing errors that can result in adverse incidents, morbidity and mortality. Therefore, it is fundamental to make a careful and responsible assessment of the risks related to these extraordinary practices. The MeDD II project members can provide expert metrological and clinical physics advice regarding issues related to infusion risks to prevent the incorrect use of drug delivery devices. As so, it is recommended that hospital management appoints a supervisor (metrology expert or has expert vision provided by metrologists to the decision making) to determine in consultation with the medical specialists, users of infusion pumps and support departments what is necessary and suitable and to advise on safe use.

How can metrology help? Three common issues related to drug infusion have been identified following the extraordinary measures and recommendations to tackle them are given below.

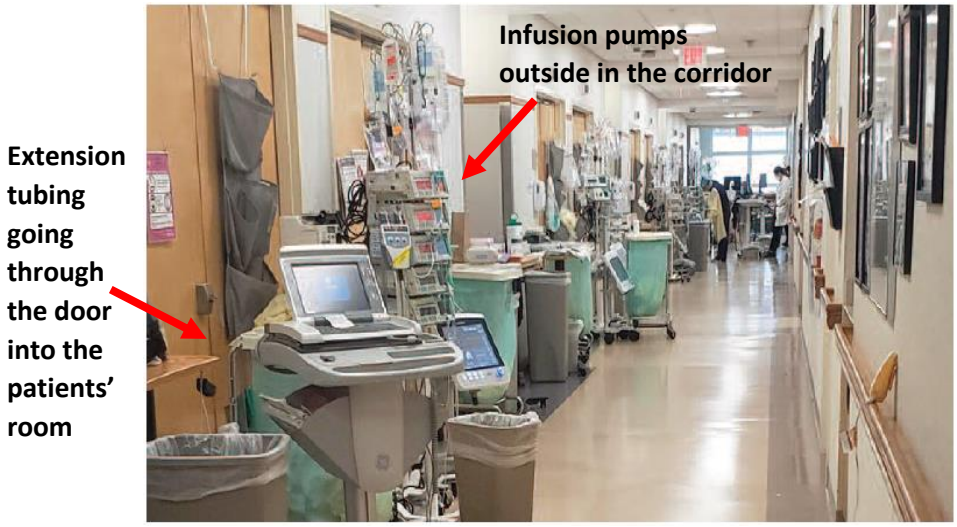
To use the drug delivery devices outside the patients' room

Several hospitals are now using extension sets to position infusion pumps outside of COVID-19 patients' rooms to preserve personal protective equipment (PPE) and reduce the frequency of exposure that nurses would ordinarily experience by going into patients' rooms to manage infusions. But this procedure raises several concerns, mainly:

1. Are the risks of these practices acceptable in order to sustain safe patient care?
2. Is the delivery through long extension tubing appropriate for the specific medication to be administered to the patient?
3. Is the accuracy of the device affected by this setup with extension sets?
4. Are there limitations in the performance of the infusion pump stated by the manufacturer?
5. Are there risks for infection?
6. Is this setup going to lead to significant preservation of PPE?

7. Are there other and/or better solutions for saving PPE use, *e.g.* remote control, robots, reusable PPE?

8. Who much wastage of now-very-scarce critical medications before enter into patient?



Example of medical equipment and infusion pumps setup using extension sets to position infusion pumps outside of hospital patients' rooms, from https://ismp.org/resources/clinical-experiences-keeping-infusion-pumps-outside-room-covid-19-patients

There are many risks associated to the infusion device setup, the first related to the **use of extension tubing** (or multiple extension sets connected in series), namely:

- the priming volume increases with extensions;
- there is an increase in fluid flow resistance;
- the flow accuracy may be affected, specially at low flow rates and there is a risk of under-infusion;
- longer extensions with smaller inner diameters and higher flow rates are most likely to cause some slowing, up to 10%;
- more bubbles may be found in the system due to incorrect priming and extra connections fluid;
- time to detect occlusions will be longer as extension length increases;
- viscous solutions, e.g. D20%, will increase the slowing effect;
- viscosity effects can occur in long extensions resulting in occlusion alarms.

The second issue is related to the **position of the instrument.** Being outside the patients' room can lead to problems related to:

- the lack of available power outlets;
- poor accessibility to corridors and to rooms. The distance and fire regulations may not be adhered to;
- drug delivery errors resulting from the lack of tube labelling inside and outside the room;
- incorrectly attached tubing which may lead to tube disconnection;
- tube routing into the patients' room while closing the door which may deflect or even seal the tubing, thus increasing fluid flow resistance;
- waste of critical drugs;

- failure of regulatory compliance when tubing is routed into negative pressure rooms.

By specifying the inner diameter and length of an extension line and the flow rate and fluid viscosity it is possible to estimate the impact on flow rate accuracy. This information can be found in www.ecri.org.

Smaller tubing is easier to route under doorways and usually less susceptible to mechanical occlusion.

The concern for delay for medication reaching the patient and the complications of dead volume when two or more medications are blended at the pump end can be mitigated by minimizing the priming volume of the extension line.

It is recommended to **test the flow rate and volume delivered** when using extension lines, especially at low flow rates. These changes will strongly impact the accuracy of the device due to modifications in the setup. Ultimately, the pump will not perform according to the specifications of the manufacturer.

All the issues above must be carefully considered by the Supervisor and team when using extensions of tubing and moving the instruments outside the patients' room. The pros and cons must be thoroughly evaluated to guarantee the staff safety as well as the patient safety.

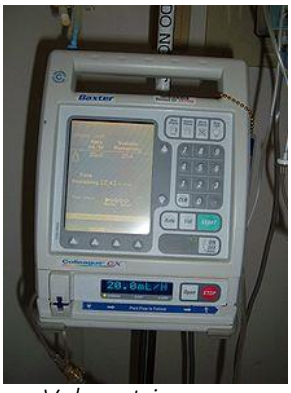
To use the drug delivery devices with associated clinical risks and lower accuracy

As a result of the impending shortages during the COVID-19 crisis, health professionals are prompted to partially replace syringe infusion pumps by lower-accuracy volumetric infusion pumps. Is possible to do so in a controlled and safe way in order to minimize clinical risks and to prevent adverse incidents, morbidity and mortality increase.

Volumetric infusion pumps can produce, due to their mechanical design, a continuously oscillating dosing error in the flow rate (Q) of approximately 1.5 mL/h, which, depending on the specific drug and treatment needs, can pose significant risks on patient safety. To ensure this oscillation of 1.5 mL/h is always less than 10% of the setpoint flow rate, a flow rate greater than or equal to 15 mL/h is required.

Replacement of syringe pumps by volumetric infusion pumps requires the latter to be set with **flow rates greater than or equal to 15 mL/h**

Syringe pump



Volumetric pump
$Q \geq 15$ mL/h

Recommendations to correctly use infusion pumps without compromising the patient safety are:

1. when replacing a syringe infusion pump by a volumetric infusion pump, a good rule of thumb is: the **flow rate** of the volumetric pump needs to be greater than or equal to **15 mL/h** to conserve the necessary accuracy;
2. the **infusion bag** needs to be connected to a separate lumen within the catheter;
3. when **connecting a syringe pump and a volumetric pump on the same lumen**, the flow rate of both pumps must be the same and individually greater than or equal to 15 mL/h.
4. when **multiple pumps are connected on the same lumen** make sure to:
    - 1st – CLOSE ALL infusion taps and stop cocks directly connected to that single lumen;
    - 2nd – exchange syringes, pumps, etc.;
    - 3rd – reactivate all pumps;
    - 4th – OPEN ALL infusion taps;

NEVER USE A VOLUMETRIC PUMP FOR:

- highly active substances, or substances having a short half-life ($t_{1/2}$);
- Noradrenaline.

If variations to manufacturer specifications related to accuracy of the results are introduced in a clinical protocol this should be validated by performance tests done by qualified laboratories, mainly National Metrology Laboratories and Accredited Laboratories, to ensure the high confidence necessary.

To postpone maintenance and calibration of equipment for patient-critical use

As a result of the impending shortages and duration of treatments during the COVID-19 crisis, health professionals are being prompted to postpone the periodic maintenance and verification services of the drug delivery devices. However, this situation can cause serious unidentified dosing errors due to the lack of metrological performance of the pumps according to manufacturer or user specification. Ultimately it can lead to adverse incidents, morbidity and mortality.

To prevent dosing errors it is of great importance to adhere to the following standards:

i. the risk of maintenance delay should be assessed, and the maximum deferral period should be determined (at most 6 month);
ii. the department must be notified, and maintenance delay should be registered in the equipment management system (at device or instrument type level). Preferably using the existing procedure for granting extension of maintenance;
iii. users must be certain that the equipment is safe to use. Preferably indicating on the equipment that maintenance has been postponed, but another method of effective communication is also conceivable. The decision to use deviating devices or otherwise, deviating from the normal procedures, should be recorded. A technical risk analysis and clinical risk analysis (within the work process of the syringe drivers is required for high-risk medical devices.

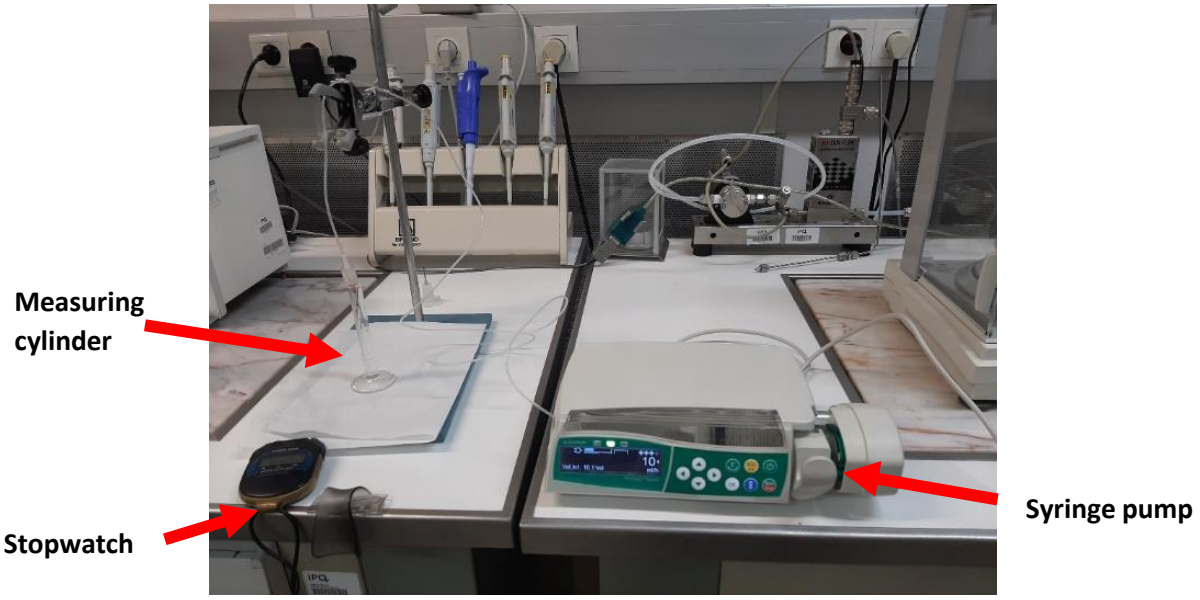
If the need for patient care allows for reduced maintenance time, a quick check can be a good alternative to a planned calibration, providing a good balance between continuity and safety of patient care.

Usually the verification of the pumps is performed:

- using a pump device analyzer by the hospital maintenance laboratory;
- using the gravimetric method by National Metrology Laboratories or Accredited Laboratories.

The internal maintenance officers can perform a quick check of the pumps dosing error using a MEASURING CYLINDER and a STOPWATCH.

This quick check method has 2 % uncertainty and can be done in 10 minutes by the internal maintenance officers, providing information on the metrological performance and maintenance status of the drug delivery device and evidence to justify extending the verification deadline.



Quick check on the performance of a syringe pump using simple lab equipment

Conclusions

To help overcome some current hospital challenges related to drug delivery devices used during the COVID-19 crisis it is recommended that procedures outside the normal work practices can be performed under controlled conditions. It is also very important to understand the clinical risks and what are the technical differences between the different pumps and their use. This will allow to avoid large dosing errors that can result in adverse incidents, morbidity and mortality.

Understanding the impact of Metrology in the use of drug delivery devices is essential to enable good decision making.

National Metrology Laboratories can significantly advance the understanding of how drug delivery devices perform. To tackle COVID-19 in extraordinary, non-ideal conditions, testing with the actual fluids used for patient infusions can help identify errors and quantify device uncertainties. These strategies enable the development of best practice and methodologies to use drug delivery devices in challenging conditions.

Further Information

Further information on metrology for drug delivery can be found at www.drugmetrology.com.

References

- https://ismp.org/resources/clinical-experiences-keeping-infusion-pumps-outside-room-covid-19-patients
- https://www.ncbi.nlm.nih.gov/pubmed/10945397
- https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/covid-19-critical-items
- https://www.ecri.org/press/ecri-institute-safe-medication-practices-join-forces-enhance-patient-safety
- https://www.intmedsafe.net/about/contact/
- https://www.ecri.org/landing-covid-infusion-therapy
- https://www.medtechdive.com/news/the-latest-coronavirus-shortage-hospital-infusion-pumps/575891/
- https://www.ivenix.com/news/next-covid-19-device-shortage-smart-infusion-pumps/?utm_campaign=Email%20RSS&utm_source=hs_email&utm_medium=email&utm_content=87376086&_hsenc=p2ANqtz-80BSXRP0tAU5mOPzJEDEa-e2J6aqBLJ3zCH6Sr7O-tdFGpIwRLIdJt-QYLovvqSBUrmBgFfhGkWMoF3vsZedsfGdTmEyiNBkNhuq9s1FYCj2pMb9c&_hsmi=87376086
- https://assets.ecri.org/PDF/COVID-19-Resource-Center/COVID-19-Clinical-Care/COVID-Alert-Large-Vol-Infusion-Pumps-3.pdf
- Optimization of the intravenous infusion workflow in the isolation ward for patients with coronavirus disease 2019, Yan Song, Wenhui Wang, Lijun Zhang, Li Sha, Guilan Lu, International Journal of Nursing Sciences, article in press
- Leidraad Kwaliteit en veiligheid van medische technologie tijdens de Covid-19 pandemie, NVKF, 28-4-2020, (Guideline Quality and Safety of medical technology during the Covid-19 pandemia, Netherlands Association of Clinical Physics)
- H. Bissig, H.T. Petter, P. Lucas, E. Batista, et al., Primary standards for measuring flow rates from 100 nL/min to 1 mL/min – gravimetric principle, Biomedical Engineering, (2015), 60(4)
- E. Batista, N. Almeida, A. Furtado, E. Filipe, L. Sousa, R. Martins, P. Lucas, H.T. Petter, R. Snijder, A. Timmerman, Assessment of drug delivery devices, Biomed.Tech. 60 (4) (2015 Aug) 347–357.