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EDITORIAL

Intravenous administration of medications during an anesthetic: a deceptively simple process

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Anesthesiologists administer at least one intravenous (IV) medication in nearly every case. An ordinary anesthetic will often employ 10 or more individual IV medications. Some medications, such as muscle relaxants, opiates and propofol, are administered IV multiple times. What are the steps, and the pitfalls, in this routine process?

First, a treatment situation is recognized. However, this may be missed. Then, the clinician formulates a diagnosis. Unfortunately, the diagnosis may be erroneous. On the basis of the diagnosis, the clinician chooses a medication to treat the condition and proceeds to administer the medication via the IV route. However, the clinician may choose the wrong drug. The chosen drug may be contraindicated for a patient allergic to the medication. He/she may choose the correct drug, but prepare it improperly (e.g. an error in dilution), administer an incorrect dose, or introduce contamination [1]. The administered drug must enter and traverse the fluid path of the IV system to reach the patient's circulation. Finally, the clinician monitors the patient for the treatment's effects.

Consider the example of new onset tachycardia in the operating room. Does the elevated heart rate result from hypovolemia, light anesthesia, hypoglycemia, a dysrhythmia or some other cause? Is the appropriate therapy a fluid bolus (crystalloid, colloid, plasma, red cells?). Should therapy include deepening of the anesthetic (narcotics, inhaled agents, dexmedetomidine, ketamine, lidocaine, propofol?). Perhaps the situation necessitates emergency administration of glucose or treatment with a specific antidysrhythmic agent (which one is the safest and most effective?)? Cognitive loads or lack of knowledge contribute to error [2].

Consider the mechanical components of IV delivery systems, which encompass the reservoir for the main fluid through to the intravascular catheter [3]. Unfortunately, the mechanical features and performances of IV delivery system components can go unappreciated [4]. In their report, Kuntz and colleagues describe a careful investigation of the properties of one component of an infusion system, the administration port [5]. They measured the dead volumes of administration ports with different designs (Y tubing, stopcocks, 1-way ports). The findings from their quantitative in vitro model demonstrate a wide range of dead volumes. These dead volumes can provide reservoirs of drugs available for inadvertent bolus. With this information, they provide estimates of potential unintended bolus doses of powerful medications including epinephrine, heparin and insulin. As Kuntz et al. point out, there are major implications for pediatric patients. This is true because the same infusion system components, e.g. stopcocks, may be used for both pediatric and adult patients. However, the tolerance of a 2–3 kg infant is vastly different than a 70–80 kg adult for the same mass of drug. Imagine the implications of a bolus of epinephrine, 8 µg, for the infant versus an adult. Errors associated with the dead volumes of injection ports potentially amplify the impact of errors with injections of small volumes [6].

Kuntz et al. also explore the implications of the dead volume for blood sampling. The data provide insights into the impact of dead volume on clinical assessment of key patient parameters including oxygenation, ventilation and hematocrit, again with particular implications for the small patient.

One might hope that clinical practice would account for infusion system component dead volumes, thereby mitigating risks for adverse events. Distressingly, the survey data suggest variations in clinical practice even within one department. An overall inference is that clinical practice may fail to provide safeguards [7], perhaps because of lack of awareness of pitfalls or the distraction of stressful clinical circumstances such as hemorrhage or an unstable cardiac condition. Furthermore, hospitals may change suppliers of IV system components because of cost or manufacturer shortfalls. Will clinicians recognize the potential

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for unfamiliar mechanical properties of components from alternative suppliers and adjust their practices accordingly?

Adverse patient care events motivated the studies conducted by Kuntz et al. The investigators demonstrate the role of quantitative, root cause, analysis at a granular level for understanding clinical events. Seemingly small factors can have substantial impacts, with safety implications especially for the most vulnerable patients. Perhaps what clinicians in all areas of medicine perceive as simple and routine in daily practices is often deceptively simple.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

References

1. Dhawan I, Tewari A, Sehgal S, Sinha AC. Medication errors in anesthesia: unacceptable or unavoidable? Braz J Anesthesiol. 2017;67(2):184–92.
2. Stiegler MP, Gaba DM. Decision-making and cognitive strategies. Simul Healthc. 2015;10(3):133–8.
3. Peterfreund RA, Philip JH. Critical parameters in drug delivery by intravenous infusion. Expert Opin Drug Deliv. 2013;10(8):1095–108.
4. Kim UR, Peterfreund RA, Lovich MA. Drug infusion systems: technologies, performance, and pitfalls. Anesth Analg. 2017;124(5):1493–505.
5. Kuntz MT, Dudaryk R, McNeer RR. Can variable practice habits and injection port dead-volume put patients at risk? J Clin Monit Comput. 2018. https://doi.org/10.1007/s10877-018-0179-3.
6. Muffly MK, Chen MI, Claure RE, Drover DR, Efron B, Fitch WL, Hammer GB. Small-volume injections: evaluation of volume administration deviation from intended injection volumes. Anesth Analg. 2017;125(4):1192–9.
7. Grigg EB, Roesler A. Anesthesia medication handling needs a new vision. Anesth Analg. 2018;126(1):346–50.