

The accuracy of medication volume delivered using prefilled “Code Cart” epinephrine syringes: A simulation study

By Domhnall O’Dochartaigh

Introduction

Epinephrine is a common resuscitation medication (US National Library of Medicine, 2017). Doses of intravenous epinephrine are given every day to pediatric patients in cardiac arrest across North America (de Caen et al., 2015). Prefilled syringes of epinephrine are popular because they can decrease medication administration delay. While supported by the manufacturer (Hansen, Eriksson, Mah, Meckler, & Guise, 2017), the accuracy of delivering small doses of epinephrine from 10 mL prefilled syringes has been questioned (Hansen, Eriksson, Mah, Meckler & Guise, 2017). We therefore performed a simulation study to assess the actual versus assumed volume of prefilled epinephrine syringes when the goal was to deliver volumes of 0.5 to 3 millilitres (mL), namely 50 ug to 300 ug.

Methods

We examined 10-millilitre prefilled epinephrine syringes containing 100 ug/mL or 1mg in 10 mL [Lifeshield Glass Abbojet, Hospira; Illinois, USA]. Our goal was to determine the actual volume expelled when the plunger was depressed to target doses/volumes: 50 ug/0.5 mL, 100 ug/1 mL, 150 ug/1.5 mL, 200 ug/2 mL, and 300 ug/3 mL. In order to measure the expelled volume, we attached a syringe-to-syringe transfer device [Braun, Bethlehem, Pennsylvania, USA]. Next, excess fluid and air was expelled from

the prefilled syringe, and the fluid was levelled to the 0 mark. We repeated this experiment using 1 mL and 3 mL syringes.

The participant (one of two critical care nurse researchers) was blinded to the volume expelled. After measurement in the transfer device, the remaining volume in the preload syringe was expelled, measured, and recorded separately. Syringe volume readings were independently verified by two nurse researchers (DOD & MJD). The first ten readings were made with new-in-package epinephrine syringes. Subsequently, following a standardized procedure syringes were refilled to the total mean volume found in the syringes to match the manufacturer’s original volume. For each trial the participant performed a syringe priming technique that mirrors everyday clinical practice. Namely, the participant held the prefilled syringe tip to eye level and expelled any excess fluid and air. A Research Ethics Community Consensus Initiative Screening Tool was utilized to determine this study did not involve human subjects and was of minimal risk (<http://www.aihealthsolutions.ca/arecci/screening>).

Results

The mean total volume of 10 prefilled syringes was 10.8 mL (95% CI 10.66–10.94). We conducted 193 separate tests with the preload syringe and 152 separate tests with the 1 mL and 3 mL syringes. See Table 1 for results.

Intended Delivery Volume in ml from 10 mL prefilled syringe	Number of tests	Mean Expelled mL (SD)	Min – Max mL	95% CI mL
0.5	65	0.51 (0.04)	0.46–0.62	0.50–0.51
1	65	1.00 (0.05)	0.90–1.13	0.99–1.01
2	35	2.05 (0.06)	1.90–2.20	2.03–2.07
3	16	3.04 (0.04)	2.98–3.10	3.02–3.06
Intended Delivery Volume in ml from 3 mL syringe				
0.5	26	0.51 (0.01)	0.49–0.53	0.51
1	25	1.01 (0.03)	0.98–1.1	1.01
2	25	2.00 (0.01)	1.99–2.03	2.00
3	25	3.01 (0.02)	2.98–3.04	3.01
Intended Delivery Volume in ml from 1 mL syringe				
0.5	26	0.51 (0.01)	0.5–0.53	0.51
1	25	1.01 (0.01)	0.98–1.03	1.01

Discussion

Reassuringly, our data confirm that with delivery of larger doses/volumes there is a smaller percentage of inaccuracy. In contrast, when small volumes are delivered the percentage inaccuracy increases. While perhaps intuitive, these findings address the concerns raised by Hansen et al. (2017). It is not known if, in previous studies that called micro-dosages of epinephrine into question, the preload syringe fluid was first depressed to zero. Regardless, they were zeroed in our study. Of note, extra fluid is provided in the syringes to prime the preload as well as purge any air. Our study is a useful reminder to undertake this important step.

Our results found that for all 193 preload tests the mean volume delivered was within 2% of the target and 95% were within 3% percent. Outlying minimum and maximum tests deviated greatest for the 0.5 mL and 1 mL target volumes (up to 24% and 13% respectively). Our work confirms what again may seem intuitive, namely that a smaller syringe may be more accurate when delivering less than 3-mL. We found lower percentage variation in the dose/volume delivered with the 1 mL and 3 mL syringe. This has been shown before (Erstad et al., 2006; Thobani & Steward, 1992), that the smallest possible syringe size should be selected. However, the use of smaller non-prefilled syringes should be balanced against the delay caused by drug preparation, namely transferring medications from vials to syringes for intravenous push administration. For example, delays commonly exceed one minute when using the drug decanting method, namely the process of drawing up a volume of drug followed by diluent (Moreira, Hernandez, Stevens, Jones, Sande, Blumen, et al., 2015). Clinicians should weigh the risk/benefit of using a preload syringe that is quicker against a smaller syringe which is more accurate at low dose. Similarly, manufacturers might consider creating smaller prefilled syringes.

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Conclusion

To increase dosing accuracy, the volume of a prefilled syringe should be zeroed prior to administration. To further increase dosing accuracy when administering smaller volumes—especially volumes less than one mL—a smaller syringe should be considered.

Author’s take-away:

1. Using prefilled syringes to administer epinephrine is common.
2. The accuracy of volume delivery has been questioned, especially when delivering lower volumes (0.5 to 3 milliliters) from a 10 mL syringe.
3. This study has found that administrating medications from pre-filled syringes is reassuringly accurate.
4. To increase dosing accuracy, the volume of a prefilled syringe should be zeroed prior to administration.
5. To further increase dosing accuracy when administering smaller volumes—especially volumes less than one mL—a smaller syringe should be considered.

About the author



Domhnall O’Dochartaigh is the Clinical Nurse Specialist for the Edmonton, Alberta, Zone Emergency Departments. His graduate education is in Trauma Sciences. He is also an Air Medical Crew (flight nurse) with the Shock Trauma Air Rescue Service. Domhnall has acted as section editor and trauma care

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