Original Article

Accuracy of Fluid Delivery Devices for the Neonate: Are the Measures Assured?

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ABSTRACT

Introduction: Delivery of accurate volumes of fluid in surgical neonates and children is crucial for the good outcome of treatment. But how accurate are the calibrations on the fluid delivery devices? **Aims:** This study seeks to verify the accuracy of these devices in common use in our practice. **Materials and Methods:** This is a cross-sectional experimental study carried out in our center; a tertiary health facility in Southern Nigeria in May 2019. Fluid delivery devices (FDDs) used in the course of treatment of our pediatric patients were randomly included in the study. The number of drops per ml of each device was obtained by counting while the fluid dropped until a 1 ml volume was delivered. The data was then collated and analyzed. **Results:** A total of 215 FDDs were included in this study. They comprised infusion giving set, Soluset (Burette) giving set, and blood giving set. The rate of delivery was 20 drops/ml (infusion giving sets), 60 drops/min (Burette/Soluset), and 15 drops/ml (Blood giving set). They were all in keeping with the labeled/assumed calibration in each of the types of FDDs $P < 0.05$. Therefore, the mean, median, and mode were the same. **Conclusion:** This study has demonstrated that the FDDs used our center are accurately calibrated and safe as they deliver volumes of fluid as labeled. The findings in this study reassure us of the dependability and accuracy of delivery of the FDDs we use in children in our center.

Keyword: *Accuracy, delivery, device, fluid, infants, neonates*

Introduction

The use of devices of various kinds in the treatment of patients is as old as the practice of medicine. These devices have continued to be refined to attain progressively improved service and outcome of treatment. Out of the many devices in use in medical treatment, those for delivery of fluids into the patient are among the most commonly used irrespective of the specialty of medicine, the age of the patient, or the type of illness. These fluid delivery devices (FDD) have been designed with various inherent qualities to ensure accurate delivery of such fluids at the appropriate rate. The accuracy of the quantities of the fluid administered is as crucial as the fluid itself in saving or harming the patient.[1] Just as the wrong fluid administered can be disastrous, wrong quantities of the right fluid can also be disastrous.[2] This accuracy of volume delivered is even more crucial in younger children and neonates because of their limited physiological reserve to compensate for any errors in quantity of fluid administered to them. While clinicians have emphasized accurate calculations of quantity of fluids to be delivered in neonates based on the assumed number of drops per milliliter for the different devices, there have been few reports of studies to interrogate the veracity of those assumed rates for the different devices as check and balance process from the end-users.[3] This is especially pertinent against the backdrop of situations where clinicians observe urinary catheters, sutures, and other such devices

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whose labeled sizes/calibrations were obviously not in agreement with their appearance. While those errors in calibration may not lead to serious harm to the patient, similar calibration errors with FDDs can lead to administration of excessive or lesser amounts of fluid than expected. Such covert errors in the amount of fluid, electrolytes, or drugs administered in neonates and infants can lead to unexpected adverse outcome of treatment including death. Apart from the possible errors in calibration, research work has shown that fluid and electrolyte imbalances following fluid administration may be due to inherent physiological responses in the patient rather than the fluid administered.[4] The assumed (manufacturers') standard fluid delivery for the common devices are: infusion giving set (IGS) delivers 1 ml of fluid with 20 drops; the soluset (burette) (SS) delivers 1 ml with 60 drops; and the blood giving set (BGS) delivers 1 ml of whole blood with 15 drops. These fluid delivery figures have been used in our practice over the years, and found to be correct, but there is no reference to back the assumption up. This study is not intended to question the reliability of the official government bodies whose duties are to ensure standards in those devices. The study simply seeks to investigate the common fluid delivery devices (FDDs) we use for surgical neonates and infants and to verify if the number of drops per ml of fluid they deliver is in keeping with the assumed standards. This will support the reliability or otherwise of these devices in use in our practice.

Materials and Methods

This is a cross-sectional experimental study carried out in the Special Care Baby Unit, Children Emergency Ward, Pediatric Surgical Ward and the theater of our center; a tertiary health facility in Southern Nigeria in May 2019. Our research question was whether the FDDs used in our center for neonates and infants set at assumed rates of drops per minute, actually delivered the expected volume of fluid without error.

The null hypothesis was that not all FDDs used in our center for neonates and infants set at assumed rates of drops per minute, actually delivered the expected volume of fluid without error.

The alternate hypothesis was that all FDDs used in our center for neonates and infants set at assumed rates of drops per minute, actually delivered the expected volume of fluid without error.

FDDs used in the course of treatment of our patients were randomly included in the study. Randomization was done by inclusion of the first device used for each day, and thereafter alternate devices (of the same type) used in that day were included. The number of drops per ml of each device was obtained by connecting the FDD to the fluid that was to be administered and hanging the drip on a stand; then filling the counting chamber halfway, the clip (regulator) is opened slowly so that the fluid expels the air in the tube. The fluid is then allowed to drop slowly into a previously calibrated test tube while the drops are counted till a 1 ml volume is attained. The number of drops to make 1 ml across the counting chamber is also counted. The FDD is then attached to the canula or any other venepuncture device which had already been fixed on the patient. The type of FDD, the make, and the type of fluid being given were recorded. The names of the makes were eliminated after collecting the data and replaced with codes to avoid identification and any consequent conflicts of interest. The four makes of IGS were identified as IGS1, IGS2, IGS3, and IGS4. The four makes of Soluset were identified as SS1, SS2, SS3, SS4, while the three makes of BGS were identified as BGS1, BGS2, and BGS3. Data was subsequently collated and analyzed on the Microsoft Excel spread sheet and the SPSS version 20.

Results

A total of 215 FDDs were used for the study. Three types of FDD were in use in our service. They comprised infusion giving set (IGS), Burette (Soluset) giving set (SS), and blood giving set (BGS). Ninety-one (42.3%) of the FDDs were IGS, 99 (46.1%) were burette (SS) giving set, and 25 (11.6%) were blood giving set [Figure 1]. Four different makes of the IGS and SS, and three makes of the BGS were encountered in the course of the study. The distribution of the devices according to make and mean number of drops per ml is shown in Table 1. Different types of

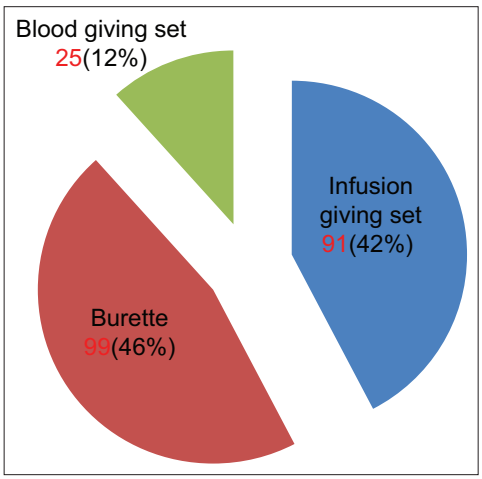

Figure 1: Types of fluid delivery devices (Original)

Table 1: Distribution of fluid delivery devices according to make and delivery rate (Original)

Fluid delivery devices	Number (*n*=215)	Mean no of drops per ml	Standard (expected) no of drops per ml
IGS1	47	20	20
IGS2	17	20	20
IGS3	18	20	20
IGS4	9	20	20
SS1	26	60	60
SS2	15	60	60
SS3	44	60	60
SS4	14	60	60
BGS1	4	15	15
BGS2	6	15	15
BGS3	15	15	15

¥ IGS- Infusion giving set; SS- Soluset; BGS- Blood giving set

Table 2: Different fluids administered and the delivery rates (Original)

Type of fluid		Frequency IGS	Mean delivery rate (drops/ml)		
			SS	BGS	
Isotonic	Normal saline	19	20	60	20
	5% Dextrose water	17	20	60	20
Hypotonic	4.3% Dextrose in 1/5 saline	97	20	60	20
Hypertonic	5% Dextrose saline	40	20	60	20
	½ 10% Dextrose water in ½ N/saline	3	20	60	20
	Mannitol	14	20	60	20
Blood		25	-	-	15

fluid were administered. All the IGS delivered 1 ml volume per 20 drops irrespective of the make of the device and the tonicity of the fluid ($P < 0.05$). All the burette (SS) giving set delivered 1 ml volume per 60 drops irrespective of the make of the device and the tonicity of the fluid ($P < 0.05$). All the BGS delivered 1 ml volume per 15 drops of blood irrespective of the make ($P < 0.05$). The mean, median, and mode number of drops per ml for each type of FDD were the same [Table 2].

Discussion

The fluid delivery devices are in very common use in our pediatric surgery service. Several different makes of each of the devices have been used to deliver fluids to our patients. Despite being manufactured by different producers, the component parts and the basic working principle are the same for all the FDDs in our practice. The findings in this study reassure us of the dependability and accuracy of delivery of the FDDs we use in our center. These devices are accurately calibrated and no manufacturer's error was recorded in the devices tested. The absence of any differences in the accuracy of the delivery of fluid between the different makes of similar devices is also reassuring that none of the makes could be considered inferior or of less quality. This study also showed that there is no affectation of number of drops per unit volume by the tonicity of the fluid administered. The role of fluid tonicity in the response to fluid maintenance remains an object of discussion among researchers.[5] The findings of this study eliminated the doubts about the correctness of the fluid delivered in our patients even when we have apparently done appropriate calculations and monitored the fluid delivery closely. The use of devices to deliver fluids and drugs by vascular access has been known to be associated with the risk of complications.[6,7] Eliminating the possibility of complications related to erroneous calibrations as shown in this study leaves the clinician with less potential complications to worry about. These findings further give us the impetus to take the correctness of the calibrations on our FDDs as a given when interrogating situations when the clinical outlook of the patient does not seem to tally with the amount of fluids believed to have been administered. The type of fluid and the electrolyte constituents, as well as the state of function of the internal organs, particularly the kidneys constitute the factors determining the ultimate outcome of fluid handling by the body.[8,9] These factors must be evaluated to ascertain their role in those situations where the clinical outlook of the patient is not in keeping with the amount of fluid believed to have been delivered by these FDDs. Patients who have some malfunctioning organ or

system will tend toward fluid overload even with the appropriate standard calculated dose given.[10] With the accuracy of the FDDs in use in our center established in this study, clinicians can focus on other confounding factors affecting the handling of fluid by the body, and accurate calculation of volumes of fluid to be delivered rather than the consideration of errors in the calibrations of the FDDs. However, it is important for clinicians to take into consideration the fact that some accessories being used with the FDD or certain features on the FDD may affect the rate of fluid delivery. It has been shown that the presence of anti-reflux valves in the FDD has the capability to impede fluid delivery.[11] The findings of this study also apply to the accuracy of drug dosages using fluids as the vehicle for their delivery. This is of particular importance in administration of antibiotics, cytotoxic chemotherapy, anesthesia, and analgesia.[12,13] The calibrations on the fluid delivery devices in our practice appear to be with high accuracy. The tested ones showed no discrepancy in their calibrations making them reliable with assured measures. On the basis of the statistical analysis of our results, we accept our alternate hypothesis which stated that all FDDs used in our center for neonates and infants set at assumed rates of drops per minute, actually delivered the expected volume of fluid without error.

We, however, acknowledge that this study did not contemplate the possibility of changes in the delivery or function of these devices after an extended period of use. This is because the assessment was done at the beginning of deployment of these devices. However, such possibility is unlikely without some physical deformation of the device.

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Conflicts of interest

The authors of this article have no conflict/s of interest with respect to this study.

References

1. Maitland K, George EC, Evans JA, Kiguli S, Olupot-Olupot P, Akech SO, *et al*. Exploring mechanisms of excess mortality with early fluid resuscitation: Insights from the FEAST trial. BMC Med 2013;11:68.
2. El-Nawawy A, Moustafa AA, Antonios MAM, Atta MM. Clinical outcomes associated with fluid overload in critically ill pediatric patients. J Trop Pediatr 2019. pii: fmz045. doi: 10.1093/tropej/fmz045. [Epub ahead of print]
3. Long E, Babl FE, Oakley E, Hopper S, Sheridan B, Duke T. Does fluid bolus therapy increase blood pressure in children with sepsis? Emerg Med Australas 2019. doi: 10.1111/1742-6723.13336. [Epub ahead of print]
4. Singhi S, Jayashree M. Children receiving conventional maintenance fluids. Indian Pediatr 2009;46:577-83.
5. Abdessalam S. Hypotonic versus isotonic maintenance fluid administration in the pediatric surgical patient. Semin Pediatr Surg 2019;28:43-6.
6. Nickel B. Peripheral intravenous access: Applying infusion therapy standards of practice to improve patient safety. Crit Care Nurse 2019;39:61-71.
7. Webster J, Osborne S, Rickard CM, Marsh N. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. Cochrane Database Syst Rev 2019;1:CD007798.
8. Kumar M, Mitra K, Jain R. Isotonic versus hypotonic saline as maintenance intravenous fluid therapy in children under 5 years of age admitted to general paediatric wards: A randomized controlled trial. Paediatr Int Child Health 2019; 29:1-6.
9. Balamuth F, Kittick M, McBride P, Woodford AL, Vestal N, Casper TC. Pragmatic pediatric trial of balanced versus normal saline fluid in sepsis: The Prompt bolus randomized controlled trial pilot feasibility study. Acad Emerg Med 2019. doi: 10.1111/acem. 13815. [Epub ahead of print]
10. Andersson A, Norberg Å, Broman LM, Mårtensson J, Fläring U. Fluid balance after continuous renal replacement therapy initiation and outcome in paediatric multiple organ failure. Acta Anaesthesiol Scand 2019. doi: 10.1111/aas. 13389. [Epub ahead of print]
11. Liu D, Keijzers G. Do SmartSite antireflux valves limit the flow rate of 0.9% normal saline through intravenous cannulas? Eur J Emerg Med 2013;20:123-5.
12. Jones TE, Selby PR, Mellor CS, Cheam DB. Ceftazidime stability and pyridine toxicity during continuous i.v. infusion. Am J Health Syst Pharm 2019;76:200-5.
13. Matsuoka A, Hirota Y, Urai S, Hamaguchi T, Takeuchi T, Miura H, *et al*. Effect of switching from conventional continuous subcutaneous insulin infusion to sensor augmented pump therapy on glycemic profile in Japanese patients with type 1 diabetes. Diabetol Int 2018;9:201-7.