Bahrain Medical Bulletin, Vol. 37, No. 3, September 2015

An Evaluation of the Effect of a Kinked Cannula on Intravenous Cannula Flow Rates

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Objective: To determine to what extent a kink would affect rates of saline flow through different gauges of intravenous cannulae.

Design: An Observational Study.

Setting: RCSI-MUB Laboratory.

Method: The flow rates of normal saline through Becton Dickinson (BD) Venflon cannulae sizes 22, 20, 18, 16 and 14 gauges (G) were measured. A kink was introduced in all cannulae immediately proximal to the catheter hub, and the flow rates were measured again.

Result: Statistical analysis showed a confidence interval overlap for flow rates in non-kinked versus kinked catheters sizes 14 G, 16 G and 18 G indicating that kinking does not significantly alter flow rate in these catheters. Ambiguity in the 20 G catheter data suggests that a greater sample size should be examined. Analysis of the 22 G catheter data showed a statistically significant decrease in flow rate when kinked.

Conclusion: Kinking was shown to have negligible effect on flow rates in 14 G, 16 G and 18 G catheters. No definitive conclusion could be drawn from 20 G data, although it was found that kinking decreased 22 G catheter flow by 9.94% on average.

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Studies on kinked intravenous cannulae are limited. In the field of critical care, when urgent fluid replacement may be required, an alteration in flow-rate through a cannula as a result of a kink would be of special interest.

Kinking of intravenous cannulae is common in the clinical setting, often occurring at the antecubital fossa or wrist joint. In a study, two brands of polyurethane cannula were compared; the incidence of minor tip distortion or shaft kinking in the clinical context occurred in 16.2% of Optiva and 23.5% of Insyte cannulae[1].

Many intravenous cannulae become kinked in the patient's arm because of patient movement at the elbow or wrist joint. The kink usually occurrs where the cannula shaft attaches to the hub; it is frequently seen by the attending nurse or doctor at the time of catheter removal. Quinton emphasized that mechanical problems rather than infection or biological rejection have been the cause of cannula failure. The mechanical problems consist of misalignment of cannula tips with blood vessels and kinks in the bends and straight portions of the Teflon tubing. These problems arise from motion of the arm with respect to the cannulae and trauma to the cannulae from external pressure"[2].

The Venflon cannulae used in our study were made of polytetrafluoroethylene (PTFE) Teflon; although, Scales stated that modern peripheral cannulae are usually made of polyurethane which is softer than PVC or Teflon; usually are kink-resistant and limit the incidence of cannula failure[3]. However, Kohler et al claimed that too flexible cannulae may kink (a small kink would significantly increase the pressure needed to maintain flow), as per Bernoulli's law or collapse, therefore, impeding the flow or causing turbulence[4].

The aim of the study is to determine if a kink would affect the rates of saline flow through intravenous cannulae of different gauges.

METHOD

The following materials were used: Fresenius Kabi standard infusion set with 15 μm filter, 25 ml priming volume and roller clamp to control flow through the drip set, 500 ml bottles of normal saline (0.9% sodium chloride), BD Venflon IV cannulae for continuous and intermittent therapy, sizes 14 G, 16 G, 18 G, 20 G and 22 G.

Figure 1 illustrates the clinical model used to measure the flow through all cannulae. The top of the water column in the drip chamber was fixed at 1 m ±5 cm above the level of the desk. For the ease of mounting, cannulae were taped to the edge of the bench, pointing vertically downwards into a 200 ml glass beaker placed on a weighing scale. Fluids and equipment were maintained at 24°C. To maximize uniformity and accuracy throughout the experiment, researchers took the responsibility for all the specific tasks.

Figure 1: Experimental Set-Up

Kinks were induced in cannulae by folding the catheter tube over itself at the point where the cannula shaft met the hub and held in this position for 10 seconds. Figure 2 shows two cannulae of different gauges having undergone the process of kinking.

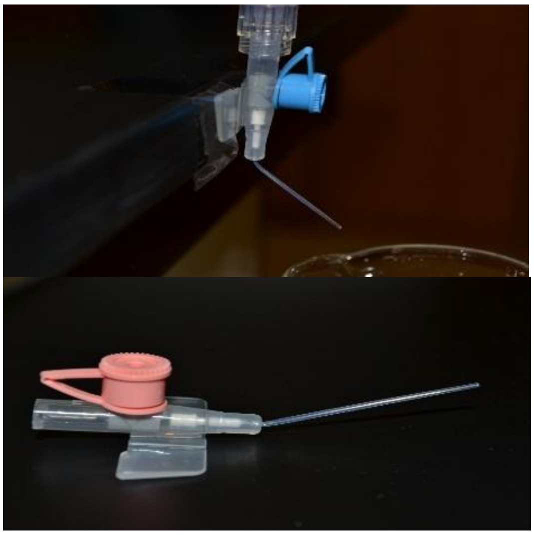

Figure 2: Kinked Cannulae; 20G and 22G Connected to Drip-Set

Flow was measured through the three cannulae, in kinked and non-kinked states. Using a timer, normal saline was run through the drip-set and cannula and into the empty beaker below for a period of 40 seconds, and the mass of saline was noted to two decimal places at 10-second interval. Flow was measured three times for each cannula, resulting in the collection of 9 average flow values for each gauge in each state (non-kinked and kinked).

Initially, to determine the flow rate for each cannula, mass increases per 10-second interval were averaged and multiplied by 6 to determine the mass of saline flowing per minute. This value was divided by 1.0046 (the weight of 1 ml of saline) to determine the flow rate in ml/min. To take the 30-second value for each cannula and simply double it (and again divide by 1.0046) produced an almost identical result because the flow rate over 40 seconds was relatively linear; therefore, this method was adopted.

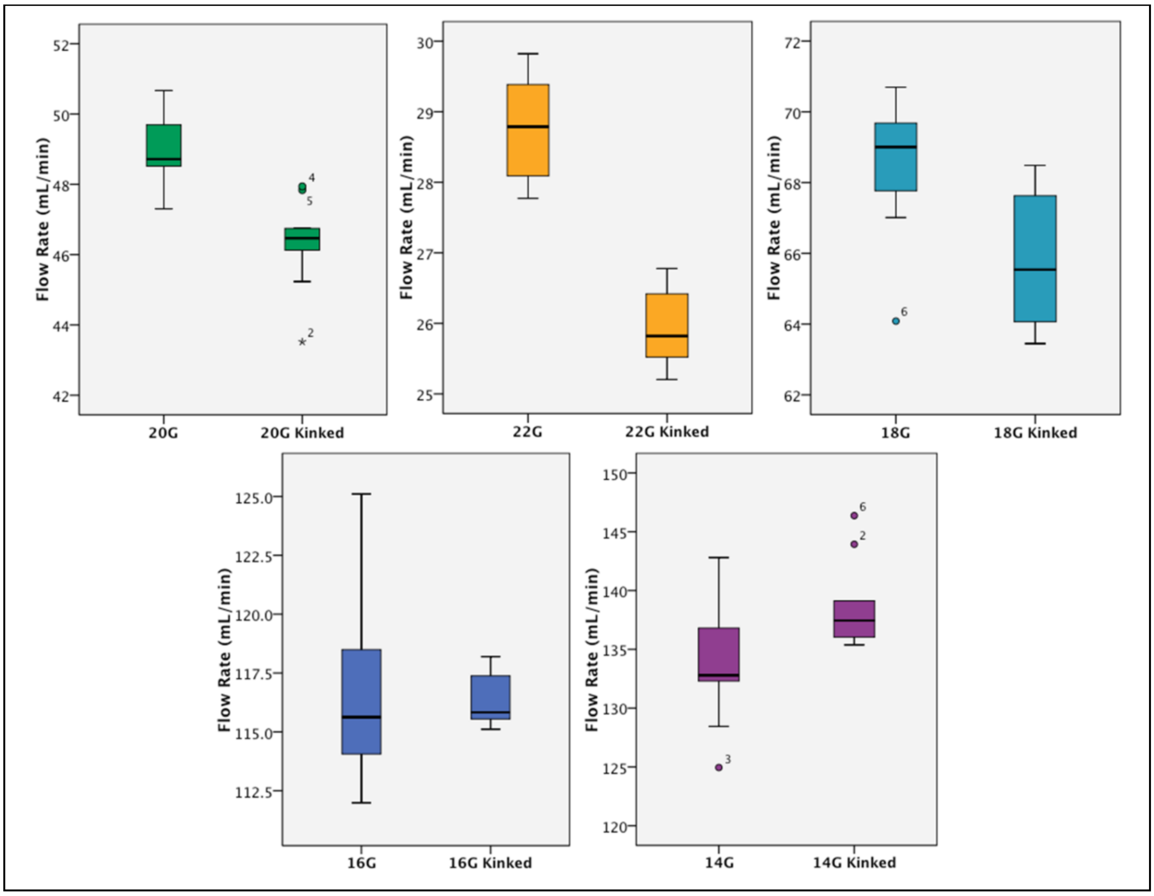

Figure 3: Comparison of Flow Rates in Non-Kinked and Kinked BD Venflon Cannulae. Flow Rates in non-kinked and Kinked Cannulae of Each Gauge Tested. Dots Represent Outliers and Stars Represent Extreme Outliers

Statistical analysis and box-plot graphing were performed using SPSS version 20. P <0.05 was considered statistically significant.

DISCUSSION

Nancarrow et al concluded that catheters marked dysfunction when completely kinked but not in the case of partial kinking[5]. Dutky et al found that kinking of the catheter introducer, a halved the flow rate of fluids through large-bore trauma tubing (805 cc/min versus 350 cc/min) but had no effect when standard intravenous tubing was utilized[6]. Standard IV tubing was used in this experiment; the above findings are in keeping with this study.

However, the results of this study also indicate that the impact of kink on flow rate varies depending on catheter gauge. Logically, the effect of kink on flow through a tube must be related to the percentage of the lumen occluded by the kink. This suggests that, although all cannulae tested in this study were visibly bent on inspection, the large-bore cannula lumens must have been occluded to a lesser extent. Assuming that the Teflon wall thickness is the same for all BD Venflon cannula gauges, it may be hypothesized that in 14 G cannula, because there is a greater volume of water travelling more quickly through the kinked section than there would be in a 22G cannula, more force is exerted on the inner luminal wall of the cannula, straightening the cannula slightly, thus reducing the extent of the kink and its impact on flow.

As no attempt was made to fix the catheters in a kinked position, it may be argued that this experiment did not recreate the clinical scenario where a patient's arm is held bent for a long period. However, an equally common clinical scenario is one where the patient flexes only briefly the joint where the catheter is fixed, and this scenario was replicated as closely as was possible in the laboratory setting.

The clinical significance of the findings is that the replacement of a kinked BD Venflon peripheral IV catheter, based on the intuitive assumption that kink will reduce flow is not merited (at least in the context of 14 G, 16 G and 18 G cannulae). Based on the finding of Dutky et al the same may perhaps not be true for large-bore trauma tubing.

Furthermore, the lack of literary evidence on the topic of cannula flow rates and kink is striking, considering that the intravenous cannula is such an indispensable clinical tool, and further studies are warranted.

CONCLUSION

The clinical significance of the findings is that the replacement of a kinked BD Venflon peripheral IV catheter, based on the intuitive assumption that kink will reduce flow is not merited, at least in the context of 14 G, 16 G and 18 G cannulae.

No conclusion could be drawn from the 20 G data, although it was found that kinking caused flow through the 22 G catheter to decrease by 9.94%.

Author Contribution: All authors share equal effort contribution towards (1) substantial contribution to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of manuscript version to be published. Yes.

Potential Conflicts of Interest: None.

Competing Interest: None.

Sponsorship: None.

Submission Date: 10 November 2014.

Acceptance Date: 14 July 2015.

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