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An Analysis of the Flow Rates in Venflon Intravenous Cannulae and Comparison with the Manufacturer's Advertised Flow Rates

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Background: Doctors rely on their clinical experience, knowledge of the Hagen-Poiseuille equation, and the manufacturer's stated flow rate on a cannula's packaging, to decide what size cannula to use in each unique clinical situation. In recent years, the Poiseuille equation has been questioned on its applicability to cannula fluid dynamics.

Objective: To validate the published flow rate of Venflon IV cannula.

Design: An Observational Study.

Setting: RCSI-MUB Laboratory.

Method: The quoted flow rates on the cannula packaging were tested in a clinical intravenous fluid delivery set-up. The goal was to assess the incremental changes in flow rates to decide whether or not the manufacturer's stated rates give a good indication of the change in flow that will be seen in practice if a doctor decided to change the size of cannula being used for infusion.

Result: The experimental and manufacturer's flow rates for the 22 G, 20 G, and 18 G cannulae are similar enough to make a little difference clinically. However, there are noticeable differences between the reported and the experimental flow rates with the larger gauges.

Conclusion: More work must be done to ensure the packaging stated flow rate and doctors must be educated on how to decide on the size of cannula to use in different clinical scenarios without relying on the package's flow rates.

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Intravenous (IV) cannulae are an integral part of modern healthcare and a tool used daily by most acute healthcare professionals. The choice of the size of the cannula to use in each clinical scenario is based on many factors. The most important factor is the rate at which fluid must be

administered. The most appropriate cannula size for the desired flow rate is chosen, while at the same time there is a need to keep the cannula as small as possible for patient's comfort[1,2].

Cannulae are usually classified by the measure of the outer diameter known as gauge. The commonly used gauges for intravenous cannulae in adults are 22 to 14 gauges. In clinical practice, the decision about the size of cannula to use is left to the doctor's individual discretion at the time of insertion.

The Hagen-Poiseuille equation is a fluid dynamics law commonly associated with flow rates through IV cannulae. This equation dictates that if the radius of the cannula is doubled, the flow rate would increase by a factor of 16. This equation guides clinicians when deciding which gauge of cannula to use according to individual infusion rate requirements. In addition, predicted flow rates are printed on the cannula packaging. For example, the BD Venflon 14 gauge cannula quotes a flow rate of 270 ml/min, while the 16 gauge quotes 180 ml/min. This allows for quick decisions when it comes to fluid infusion requirements, and it is the doctor's clinical experience that guides which cannula would be required in each unique clinical scenario.

Recently, the applicability of the Hagen-Poiseuille equation has been questioned and proven to be inaccurate in the case of IV cannula fluid dynamics. This is believed to be due to the turbulent flow of fluids in the tubing and the cannula[3]. Therefore, with the "double the radius- increase flow by sixteen" rule of thumb being phased out of use, dependence on clinical experience and the manufacturer's reported flow rate on the packaging is increasing.

The aim of this study is to evaluate and measure the flow rates of individual cannulae and then compare our results with the published results printed on the cannula packaging.

METHOD

We used BD Venflon Luer-Lok IV cannulae, sizes 14, 16, 18, 20, and 22 gauges, as these were the most commonly used cannulae in our hospital. We used the Fresenius Kabi giving set, MS 10 with a 15-micrometer filter and 25 ml priming volume. A 500 ml 0.9% normal saline solution (Pharmaceutical Solutions Industry) was used as our fluid. The mass measurements were performed using an Adam AQT 200 weigh scale, with a 0.01g differentiation.

A simulated clinical IV set-up was built in the laboratory, consisting of 500 mL 0.9% normal saline bag hanging at a height that set the top of the water column in the drip chamber to 100 cm (+/- 5cm) above the injection port on the cannula. The cannula was then fixed to the desk using tape and was pointed straight down into an empty beaker at the same angle and height for every trial. A roller clamp was used to turn flow on and off. The fluid used was standard 0.9% normal saline solution at a room temperature of 24°C. Three cannulae from each size (22, 20, 18, 16, 14 gauges) were used to control possible manufacturing defects or differences between individual cannulae of the same size. For each of the three cannulae at a given gauge, three trials were run. Therefore, we had a total of fifteen individual cannulae used and three trials for each cannula, giving us a total of forty-five trials.

Each trial consisted of measuring the flow rate of saline through the cannula by recording the mass of fluid that accumulated in a beaker at 10-second intervals over 40 seconds total. This gave us four different flow rates within each 40-second period, and these flow rates were used to ensure a consistent flow rate over the course of the trial. This also allowed us to verify that our experimental and data recording methods were consistent and accurate. For our data analysis, we used the mass at 30 seconds from each trial and converted this to a flow rate in grams per minute. This was then divided by the density of 0.9% saline at 24°C (1.0046 g/mL) to obtain the flow rate in milliliters per minute.

Using the flow rates from each trial, we averaged all nine trials for each gauge (three trials per individual cannula for three individual cannulae at each gauge) to obtain a final experimental average flow rate for each size cannula, which we used to graph against the manufacturer's reported flow rates. Two individuals performed the experiment; one recording the mass at each 10-second interval, while the other counted out loud as the stopwatch recorded 40 seconds. The same individuals performed the same duties throughout the entire experiment to keep any possible human error or bias consistent throughout all forty-five trials.

RESULT

Based on our results for the 22 G, 20 G, and 18 G cannulae, the experimental and manufacturer's flow rates are similar enough to make a little difference clinically. However, there are noticeable differences between the reported and the experimental flow rates with the larger gauges. On the graph, the slopes of the two lines begin almost parallel, and while the manufacturer's reported rates seem to take a sudden jump at the 16 and 14 gauges, the slope of the line for our values experiences change. This lack of exponential increase in our experimental values surprised us and encouraged us to re-check our method, but we were unable to reproduce the manufacturer's flow rates with the 14 G and 16 G cannulae.

The average experimental flow rates found for each gauge as well as the manufacturer's reported flow rates are presented and compared in the table 1 and figure 1.

Table 1: Average Experimental Flow Rates Obtained for Each Size Cannula and the Manufacturer's Reported Rates

Gauge	Experimental Flow Rate (mL/min)	Reported Flow Rate (mL/min)
22	28.77 +/- 0.50	31
20	48.91 +/- 0.77	54
18	68.52 +/- 1.34	80
16	116.85 +/- 2.81	180
14	134.05 +/- 3.69	270

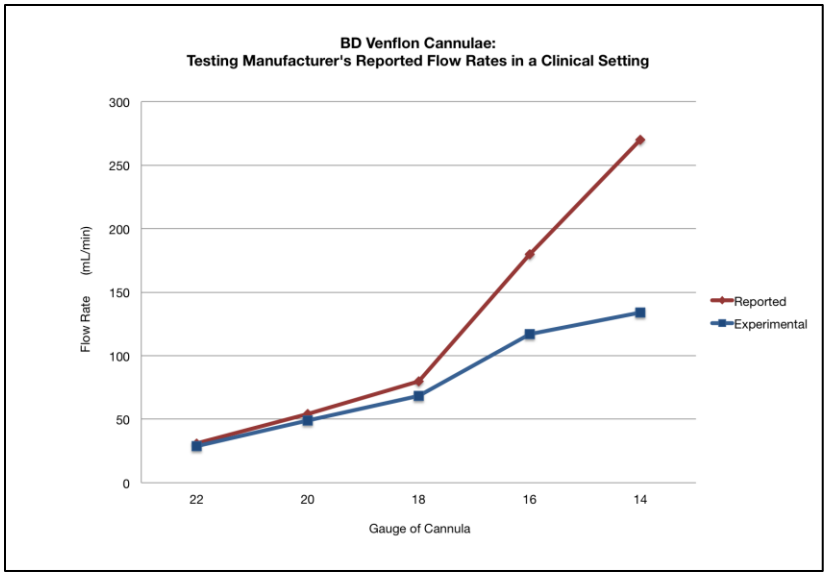

Figure 1: Line Graph Illustrating the Manufacturer's Reported Flow Rate (Red) and Our Experimental Flow Rate (Blue) for the BD Venflon IV Cannula at Each of the Commonly Used Gauges

DISCUSSION

In addition, our results demonstrate that Poiseuille's equation does not apply to flow through these cannulae, presumably because the flow is turbulent rather than laminar.

Our findings are of particular significance because we use larger gauges in emergency situations such as hypovolemic shock. Therefore, if the actual flow rates are lower than those reported on the packaging, doctors need to be aware of this to raise the patient's blood volume quickly and adequately.

This is not the first time it has been found that experimental flow rates are less than manufacturer's published flow rates[3]. Our findings closely match those of McPherson's et al. In 2009, McPherson concluded that not only can we not use Poiseuille's law to accurately predict changes in cannula flow rates, but we also should not depend fully on the manufacturer's reported flow rates to accurately reflect the flow rates that would be seen in practice. Our study differs from McPherson in two respects, as we used a different brand of cannulae and did not use a simulated vein or simulated blood in our experiments.

Although our work was specific to the BD Venflon brand of IV cannulae, we suggest that all manufacturers of IV cannulae ensure that their packaging is labeled with a flow rate calculated in a published standardized way. For example, a simple statement of "0.9% saline at 24°C, drip chamber at 100 cm above cannula" could be enough to give context to the stated flow rate and increase the applicability of the value.

We acknowledge differences between our experimental set-up and that of the manufacturer's standardized test[4]; however, we feel this should make a little difference to the ratio seen between

flow rates in cannulae at different sizes. Regardless of the absolute values for flow rates, or the method used by manufacturers to obtain their reported rates, we emphasize that the important information for physicians is the relative increase or decrease in flow seen when using different sized cannulae.

CONCLUSION

The manufacturers need to ensure that the reported differences between their cannulae's flow rates are more representative of what will be seen in practice, rather than aiming for agreement with expected flow based on the Poiseuille equation or traditional thoughts on fluid dynamics.

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