IS THE IV OBSTRUCTED OR INFILTRATED? A SIMPLE CLINICAL TEST

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ABSTRACT. Objective. The objective of our study was to determine if clinical observation of pressure-flow relationships (PFR) can differentiate between partial external obstruction (obstruction) and infiltration as a cause of poor performance of gravity-fed infusions. Methods. A total of 24 patients with functional intravenous cannulae in situ had obstruction simulated by the application of a tourniquet proximal to the cannula. The change in flow (ΔF) for a discrete change in pressure (ΔP) was determined in each case by counting drop rates at two different elevations of the fluid reservoir level, 10 cm apart. The same process was repeated in 15 patients in whom the cannula was in an extra vascular location (infiltration). Three sizes of cannula—16-gauge, 18-gauge, and 20-gauge—were examined, with equal distribution of sizes in each group. The effect on flow rates of inflating a blood pressure (BP) cuff proximally on the cannulated limb was assessed. The ratio ΔP/ΔF is the total resistance of the infusion system, and by subtracting known values for resistance of infusion tubing and cannula, the venous or tissue resistance was calculated. Results. There was a statistically significant difference between the change in flow for obstructed compared with infiltrated cannulae for the same change in pressure for each cannula size. The mean venous resistance was 23 mm Hg/L/hr, while that of tissue was 280 mm Hg/L/hr, with no overlap between groups. There was no effect on flow rate with blood pressure cuff inflation in the infiltrated group whereas flow progressively fell in the obstructed group. Conclusions. Clinical observation of PFRs in poorly functioning gravity-fed IV infusions can assist in detecting infiltration as a cause. Inflation of a blood pressure cuff will further impair flow where the cannula is intravascular, but will have no effect in an extravascular location.


INTRODUCTION

Intravenous (IV) therapy plays a significant role in the routine care of medical and surgical patients, for the administration of both drugs and fluids. Although considered a safe and effective practice, complications are common, and include phlebitis [1,2], thrombosis [3], catheter obstruction, and infiltration [4,5] (also known as "fluid extravasation" or "tissuing").

Specialist IV therapy teams, through better surveillance, have managed to reduce the incidence of phlebitis; but, they have been no more successful than routine care in preventing infiltration [6]. Accidental injection of irritant drugs into infiltrated cannulae can, at best, cause pain, and, at worst, lead to necrosis of the overlying skin [7].

Clearly, infiltration is a major clinical problem and is often difficult to detect. A mechanical means to determine the difference between infiltration and obstruction
in a poorly functioning IV has been described [8,9]; but, the technology is not readily available. The basis of this method lies in the wide disparity between the pressure-flow relationships (PFR) of tissues and veins, such that for a given increase in pressure (ΔP), a smaller incremental increase in flow (ΔF) occurs in the infiltrated cannula compared to one still within the vein lumen. In other words, the resistance of tissues is greater than that of veins.

In this paper, we have set out to determine if infiltration can be differentiated from obstruction by simple clinical measurement of the PFR of gravity-fed IV infusions using a stopwatch.

**METHODS AND MATERIALS**

Data were collected on the PFR of IV infusions established in routine surgical patients undergoing regional or general anesthesia for a variety of operative procedures. There were no special selection criteria used. All studies were performed with the approval of the hospital’s Committee for the Protection of Human Subjects from Adverse Research Risks. Written informed consent was obtained when required. Patients in whom an extravascular location was produced inadvertently during attempted IV cannula insertion (2 out of 5 for 16 gauge; 3 out of 5 for 18 gauge; 0 out of 5 for 20 gauge) or was produced purposefully during general anesthesia in patients who had consented (3 out of 5 for 16 gauge; 2 out of 5 for 18 gauge; 5 out of 5 for 20 gauge), were chosen to represent infiltration. One purposeful infiltration was produced and studied in a consenting investigator (included above and approved by the Human Subjects Committee). In the consenting volunteers, the catheter was placed in a location adjacent to a vein that appeared similar to that which was successfully cannulated. Lactated Ringer’s solution was used for all infusions.

The scenario of an obstructed cannula was simulated by applying a rubber Penrose tourniquet 5 cm proximal to the insertion site of a correctly placed IV cannula to impose a significant impairment to normal gravity-fed flow. It has been previously established that such a maneuver generates an extraluminal occluding pressure of the order of 30 mm Hg, and affects the PFR in a manner similar to cannula obstruction [10].

In all cases, a Baxter Quik-Cath (Baxter Healthcare Corporation, Deerfield IL) cannula was used and, in keeping with the most common sizes used at our institution for prolonged IV therapy, only 16-gauge × 2-in (5-cm), 18-gauge × 2-in (5-cm), and 20-gauge × 1.25-in (3.2-cm) cannulae were examined. A total of 8 patients for each size of cannula in the obstructed group (n = 24) and five patients for each size in the infiltrated group (n = 15) were included in the study. Cannulation was performed in either the hand or the forearm.

The obstructed or infiltrated cannula was connected to a standard infusion set (10 drops/ml, 0.112-in ID [28-mm], Medical Parameters, Inc., Woburn, MA), supplied by a 1-L bag of lactated Ringer’s solution. The height of the bag was not standardized; it was positioned such that each individual would permit an accurate visual count of the drop rate with the roller clamp fully open. A count was made of the drop rate over a 20-sec period, or until 8 drops had fallen, if a system was particularly slow. The rate per minute was calculated. The bag was then raised 10 cm, and the measurement repeated. Thus, the change in flow for a discrete change in pressure was determined in each case. All measurements were made with the patient still and supine. The mean change in flow for each size of obstructed cannula was compared with that of the same size of infiltrated cannula using Student’s t-test for unpaired data.

The ratio of ΔP/ΔF is the total resistance of the infusion system, comprising the additive resistances of the IV tubing, cannula, and peripheral vein or tissue. Utilizing previously published data [10], a calculation was made of peripheral venous and tissue resistance for the obstructed and infiltrated cannulae, by subtracting the resistance of the cannula and tubing from the total. These values are reported in the units mm Hg/L/hr (hereon referred to as resistance units [RU]) to be consistent with that in previous work, and calculated from our data (and 10 drops/ml) using the conversion factor:

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1 \text{ mm Hg/L/hr} = 1 \text{ RU} = 0.0078 \text{ cm water/drop/min}
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It has been suggested that an inflated blood pressure cuff proximal to the site of cannula insertion can distinguish between obstruction and infiltration, since flow will be unaffected in the latter case [11]. To test this hypothesis, each infusion was allowed to run freely with the fluid bag at a constant height; a blood pressure cuff was inflated proximal to the cannula in the next tissue compartment. The change in flow rate in terms of fall, if any, in drop rate as the cuff was inflated was assessed.

**RESULTS**

The results are summarized in the Table. The inflated blood pressure cuff failed to affect the flow through...