Syringe Size Effect on Delivered Versus Calculated Dosages of Propofol: A Bench Experiment Using the Baxter InfusOR Syringe Pump

Randall W. Klotz, CRNA, MEd, MSN

Each year thousands of anesthetics are undertaken using the Baxter InfusOR syringe pump. Anesthesia providers use various configurations, consisting of 20-, 30-, or 60-mL syringes, when delivering propofol with this syringe pump.

The Baxter InfusOR syringe pump uses the smart label system to deliver a variety of drugs. For propofol the smart label indicates that a 60-mL syringe should be used. Anesthesia providers using 30-mL syringes estimate that the delivered dose of propofol is approximately one half the set dose and that using a 20-mL syringe delivers one third the set dose. Some anesthesia providers have noted that patients are not at the level of sedation desired for a set dose. Therefore, the question arises whether syringe size adversely affects the delivered dose.

In this study, the author compared delivered vs calculated dosages of propofol using the Baxter InfusOR syringe pump with 20-, 30-, and 60-mL syringes. In addition, the author examined the ethical and legal implications of using a syringe other than a 60 mL when delivering propofol with a Baxter InfusOR syringe pump.

Keywords: Anesthetic delivery systems, conscious sedation, propofol, syringe pumps, unconscious sedation.
rations in Figures 1 through 3 represent various configurations currently used by anesthesia providers for intravenous sedation or total intravenous anesthesia (TIVA).

In discussions with anesthesia colleagues across the nation, there is a general consensus that either a 20- or 30-mL syringe can be used with the InfusOR syringe pump. There is further consensus that using either a 20- or 30-mL syringe delivers one-third to one-half the dose (in micrograms per kilogram per minute) set with the top switch, respectively. This is a false assumption, as this study finds.

Baxter has identified on each drug-specific label the drug concentration, as well as dilution instructions if applicable, and the syringe size to be used for that drug. In the Pump User’s Manual,1 Baxter has printed the warning: “the proper drug concentration and syringe size must be used for each smart label or inaccurate dosing will occur.” However, when the provider uses a 20-mL or 30-mL syringe, rather than a 60-mL syringe as indicated by Baxter, what dose of propofol is really being delivered?

To determine and compare the doses delivered with a 20-, 30-, or 60-mL syringe, a bench experiment was designed and carried out.

Materials and Methods
The parameters used for the Baxter InfusOR syringe pump were weight, 70 kg; propofol dosage, 100 μg/kg/min; and time interval, 30 minutes. Each dose of propofol was delivered into a small, round metal basin and measured at completion of a 30-minute infusion.

Taking this further, doses of propofol were calculated mathematically and compared with the delivered doses of propofol for 20-, 30-, and 60-mL syringes. To accomplish this mathematically, the internal diameter and radius (r) of each syringe had to be determined. Next, the area (A) of each syringe was determined. This was done mathematically, using the formula $A = \pi r^2$, or area equals pi multiplied by the square of the radius. To complete the calculation, the descent rate of the pusher arm assembly of the InfusOR syringe pump was determined. The pusher arm assembly has a constant descent rate of 7.2 cm/h or 3.6 cm per 30 minutes.

Results
As expected, in the first part of the experiment, at the preset parameters, the delivered doses of propofol greatly differed, depending on syringe size. In a comparison of 20- and 30-mL syringes with a 60-mL syringe, the delivered dose of propofol was approximately 48.8% and 70.9%, respectively, of that with the 60-mL syringe. Table 1 illustrates the doses of propofol delivered with these various syringe pump configurations.
The second part of the experiment calculated the diameter, radius, and area of the 3 syringe sizes. Table 2 shows these approximate measurements for each syringe. Table 3 illustrates the mathematically calculated dosages of propofol based on the equation: \( A = \pi r^2 \) (descent rate in cm²).

When delivered and calculated doses were compared, it was evident that syringe size variably affects the doses of propofol delivered when identical parameters are set.

### Discussion

This bench experiment not only demonstrated large dosage differences depending on syringe size but also identified potential legal and ethical concerns. What are these potential legal and ethical concerns?

To begin, certain legal terminology must be introduced and defined. A **tort** is defined as “a civil wrong committed against another, either through an act of omission or commission.” **Negligence** is defined as “an act that was not intended to produce the wrong result that followed” and is a type of tort.² ³ **Standard of care** is a “legal term used to describe the required expertise” to perform anesthesia. The standard of care compares a provider’s practice to the practice of a pool of providers, and is legally enforceable.² ³ The American Association of Nurse Anesthetists (AANA) Scope and Standards for Nurse Anesthesia Practice⁵ “offers guidance for Certified Registered Nurse Anesthetists (CRNAs).” Anesthesia is provided by CRNAs and anesthesiologists, yet both providers must adhere to the same standard of care. This duality is due to advances in anesthesia that have been adopted by both types of anesthesia providers.⁶ **Duty** is basically the level of care that a provider provides the patient based on the provider’s level of education, professional certification, and the standard of care for his or her given profession.² ³ ⁶ **Breach of duty** is any departure from the standards of care or a “failure to act in accordance with those norms by any commissive or omissive act violating the standards of care.”² ³ ⁶

As discussed earlier in this article, Baxter has warned anesthesia providers, or other InfusOR syringe pump users, that the proper size syringe, either a 20- or 60-mL syringe, must be used as indicated on the drug-specific smart labels, or dosing will be inaccurate.¹ For propofol, a 60-mL syringe is required. Therefore, the use of a 20- or 30-mL syringe would be construed as an act of commission, making it an act of negligence. Furthermore, the AANA Position Statement 2.12, Unintended Awareness Under General Anesthesia,⁷ defines various causes of intraoperative awareness. Primarily, this would be insuf-

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**Table 1. Measured Dosage Differences Using Different Syringes**

<table>
<thead>
<tr>
<th>Syringe size (mL)</th>
<th>Propofol (mL)</th>
<th>Propofol dosage (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>10.6</td>
<td>106</td>
</tr>
<tr>
<td>30</td>
<td>15.4</td>
<td>154</td>
</tr>
<tr>
<td>60</td>
<td>21.7</td>
<td>217</td>
</tr>
</tbody>
</table>

**Table 2. Internal Diameters, Radii, and Area of Different Syringes**

<table>
<thead>
<tr>
<th>Syringe size (mL)</th>
<th>Internal diameter (cm)</th>
<th>Radius (cm)</th>
<th>Area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2.0</td>
<td>1.0</td>
<td>3.14</td>
</tr>
<tr>
<td>30</td>
<td>2.4</td>
<td>1.2</td>
<td>4.52</td>
</tr>
<tr>
<td>60</td>
<td>2.8</td>
<td>1.4</td>
<td>6.16</td>
</tr>
</tbody>
</table>

**Table 3. Calculated Dosage Differences Using Different Syringes**

<table>
<thead>
<tr>
<th>Syringe size (mL)</th>
<th>Propofol (mL)</th>
<th>Propofol dosage (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>11.3</td>
<td>113</td>
</tr>
<tr>
<td>30</td>
<td>16.3</td>
<td>163</td>
</tr>
<tr>
<td>60</td>
<td>22.2</td>
<td>222</td>
</tr>
</tbody>
</table>
ficient or inadequate dosing or delivery of the anesthetic agent, as would occur if a 20- or 30-mL syringe were used for propofol administration with the InfusOR syringe pump. This position statement further elaborates that “insufficient or inadequate dosing can result from either failure or misuse of anesthesia equipment, including infusion pumps.” Therefore, this statement would further support the use of a syringe size not recommended by the pump manufacturer as an act of negligence through an act of commission.

A review of anesthesia records shows disparity between anesthesia providers when documenting a propofol infusion. Figure 4 depicts the 2 ways that anesthesia providers document a propofol infusion on the anesthesia record. Some anesthesia providers chart propofol infusions simply with a line and total dose at the end, as seen in Figure 4a. This is justified as “titrating to effect.” Other anesthesia providers chart their propofol infusions with all doses (micrograms per kilogram per minute) throughout the infusion, with a total at the end, as seen in Figure 4b. Therefore, what is the proper format for charting a propofol infusion on the anesthesia record?

The Code of Ethics for Certified Registered Nurse Anesthetists was adopted as a professional guideline for CRNAs. In section 3.2, “Responsibilities as a Professional,” it states that “the CRNA practices in accordance with the professional practice standards established by the profession.” Blumenreich, in his Legal Briefs column titled “Charting,” states the scope and standards for nurse anesthesia practice, adopted by the AANA, and in standard VI provides: “There shall be complete, accurate, and timely documentation of pertinent information on the patient’s record.” This is interpreted, according to Blumenreich, to justify the statement, “document all anesthetic interventions and patient responses” and that failure to do so “creates the negative inference that proper monitoring did not occur.”

Furthermore, the AANA publication Documenting the Standard of Care: The Anesthesia Record states that “there is tremendous variation in the type of information found on the anesthesia record and in the way it is entered.” This AANA paper further states that “anesthesia care normally is documented on a graphic anesthesia record, which includes a sequence of entries reflecting the anesthesia care given, the drugs and fluids administered and the patient’s responses to the care.” The American Society of Anesthesiologists (ASA), in its Statement on Documentation of Anesthesia Care, developed by the Quality Management and Departmental Administration Committee and approved by the ASA House of Delegates, states in section IIC that “doses of drugs and agents used, times and routes of administration should be recorded in a time-based record of events.”

In a text by Dornette the anesthesia provider is instructed to chart each anesthetic agent or drug by percent concentration, appropriate units of measurement, and dosages. Furthermore, in Table 10-1, Documentation of Anesthesia Care, the anesthesia provider is instructed to record not only the amounts of drugs or agents used but also the times given.
Therefore, just as anesthesia providers document changing concentrations of anesthetic gases as they occur on the anesthesia record, so should changes in the infusion rates (in micrograms per kilogram per minute) of propofol. Therefore, the statements and inferences of the AANA and ASA, as well as the statement in the text *Legal Issues in Anesthesia Practice*,2 support the method of charting propofol infusions as noted in Figure 4b.

**Conclusion**

This bench experiment demonstrates major differences in doses of propofol administered when a 20-, 30-, or 60-ml syringe is used with the Baxter InfusOR syringe pump infusion device. The use of a 60-ml syringe with the InfusOR syringe pump is mandated by the manufacturer’s instructions found in the *Pump User’s Manual*1 for the proper and accurate dosing of propofol. The standard of care, as established by the AANA and ASA, and position statements by each professional organization, also supports the use of a 60-ml syringe with the InfusOR syringe pump. Furthermore, the standard of care of both the AANA and ASA for documenting the patient’s care on the anesthesia record supports the charting of propofol infusions using doses of propofol (in micrograms per kilograms per minute) in a time-based fashion.

Failure to use a 60-ml syringe for the infusion of propofol with an InfusOR syringe pump, as well as failure to document the doses of propofol in micrograms per kilogram per minute as the dose changes, could be construed as a breach of duty and violation of the standard of care. Therefore, the anesthesia provider would be committing negligence via acts of commission and omission.

Anesthesia providers should be aware of these implications when using the Baxter InfusOR syringe pump.

**REFERENCES**


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