Clinical Evidence Review

A regular feature of the American Journal of Critical Care, Clinical Evidence Review unveils available scientific evidence to answer questions faced in contemporary clinical practice. It is intended to support, refute, or shed light on health care practices where little evidence exists. To send an eLetter or to contribute to an online discussion about this article, visit www.ajcconline.org and click “Respond to This Article” on either the full-text or PDF view of the article. We welcome letters regarding this feature and encourage the submission of questions for future review.

OBTAINING BLOOD SAMPLES FROM PERIPHERAL INTRAVENOUS CATHETERS: BEST PRACTICE?

By Margo A. Halm, RN, PhD, CNS-BC, and Melissa Gleaves, RN, BSN

Occasionally, nurses perform phlebotomy via intravenous catheters, especially to improve efficiency in short-stay or procedural units. The intent of this practice is to reduce the number of venipunctures and thus increase patients’ comfort. However, obtaining laboratory specimens from peripheral intravenous catheters may hemolyze the specimens, and can even dislodge catheters and necessitate restarts. Both of these scenarios may lead to multiple needle sticks and delayed treatment, not only reducing patients’ satisfaction but also increasing costs of care.¹

Hemolysis is a rupture of red blood cells with a release of hemoglobin and other intracellular contents into the plasma.² In vitro hemolysis interferes with tests such as blood bank/coagulation testing and measurement of levels of creatine kinase, lactate dehydrogenase, potassium, iron, digoxin, alanine and aspartate aminotransferase, and β-human chorionic gonadotropin.³ Depending on the level of hemolysis, specimens may need to be rejected and another sample would need to be collected.

Overall, hemolyzed specimens account for nearly 60% of rejected specimens.¹ Factors that contribute to hemolysis vary from anatomical and physiological characteristics to equipment and techniques used during phlebotomy.¹ According to the American Society for Clinical Pathology,² a 2% hemolysis rate is considered best practice. In this review, we synthesize available evidence about the effect of collecting blood samples for laboratory tests from peripheral intravenous catheters on hemolysis rates in the specimens.

©2009 American Association of Critical-Care Nurses
doi: 10.4037/ajcc2009686

Methods

MEDLINE and CINAHL were the search engines used. Key search words were phlebotomy, intravenous catheters, Vacutainers (Becton, Dickinson, and Company, Franklin Lakes, New Jersey), and hemolysis. Both research evidence and manufacturers’ evidence were included.

Results

Eight studies were retrieved (Table 1). Designs included observational, descriptive, comparative, and experimental. In half of the studies,2-6-8 hemolysis was compared between specimens collected from intravenous catheters and specimens collected from venipunctures; in 1 study,⁵ hemolysis was compared between 5- and 10-mL tubes; and in 3 studies,¹,³,⁴ causes of hemolysis of specimens obtained from intravenous catheters were investigated. In most of the studies, hemolysis was assessed via visual inspection to detect a color change indicating presence of hemoglobin; in a few studies, researchers used spectrophotometers or daily comment logs.

Rates of Hemolysis

Hemolysis varied considerably between methods and units. Hemolysis occurred in 3.3% to 77% of blood samples obtained via intravenous catheters, whereas it occurred in only 0% to 3.8% of blood samples obtained via venipuncture. Hemolysis of samples obtained from intravenous catheters via different methods ranged from 5.6% to 77% for samples obtained with a Vacutainer, 3.3% to 49% for samples obtained with a syringe, 12.8% to 49% for samples obtained from new intravenous catheters, and 24% for samples obtained from established
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. and setting</th>
<th>Design</th>
<th>Hemolysis, % or amount&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Factors associated with hemolysis&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Anatomic</th>
<th>Equipment</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowe et al&lt;sup&gt;2&lt;/sup&gt;</td>
<td>853 specimens, emergency department</td>
<td>Crossover: intravenous catheter (Vacutainer at hub) vs venipuncture (butterfly with Vacutainer)</td>
<td>5.6% (intravenous catheter) vs 0.3% (venipuncture)</td>
<td>Intravenous catheter/ Vacutainer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dugan et al&lt;sup&gt;3&lt;/sup&gt;</td>
<td>382 specimens, emergency department</td>
<td>Observational: New intravenous-catheters with extension tubing (syringe or Vacutainer)</td>
<td>12.8%</td>
<td>Right hand/forearm/ antecubital Discharge diagnoses: respiratory, gastrointestinal, reproductive, dermatological, endocrine</td>
<td></td>
<td></td>
<td>22-gauge intravenous catheter 1.8-mL tube</td>
</tr>
<tr>
<td>Cox et al&lt;sup&gt;4&lt;/sup&gt;</td>
<td>268 specimens, emergency department</td>
<td>Crossover: intravenous catheter (5-mL vs 10-mL tubes)</td>
<td>Hemolysis amount 0.5 (none to slight) with 5-mL tube vs 1.8 (slight to moderate) with 10-mL tube</td>
<td>Larger tubes (10 mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant&lt;sup&gt;5&lt;/sup&gt;</td>
<td>454 specimens, emergency department</td>
<td>Comparative: intravenous catheter vs venipuncture (butterfly), both either Vacutainer or syringe</td>
<td>49% (new intravenous catheter) vs 24% (existing intravenous catheter), vs 3% (butterfly) 77% (intravenous catheter/ Vacutainer) vs 28% (intravenous catheter/syringe)</td>
<td>New catheters New catheters with Vacutainer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burns and Yoshikawa&lt;sup&gt;6&lt;/sup&gt;</td>
<td>4021 specimens, emergency department vs medical unit, 204 collections, (emergency department vs phlebotomy)</td>
<td>Retrospective Observational: Hemolysis risk factors</td>
<td>12.4% (emergency department) vs 1.6% (medical unit)</td>
<td>Distal veins 22-gauge (vs 20-gauge) intravenous catheters Plastic (vs metal) intravenous catheters</td>
<td></td>
<td></td>
<td>Tubes filled less than halfway</td>
</tr>
<tr>
<td>Seemann and Reinhardt&lt;sup&gt;7&lt;/sup&gt;</td>
<td>19 specimens, medical unit</td>
<td>Quasi-experimental: Intravenous catheter (Vacutainer at intermittent infusion cap) vs venipuncture (Vacutainer)</td>
<td>21% (intravenous catheter) vs 0% (venipuncture)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carraro et al&lt;sup&gt;8&lt;/sup&gt;</td>
<td>27 540 specimens, internal medicine, surgery, transplant, intensive care unit, emergency department</td>
<td>Observational: Hemolysis causes</td>
<td>3.3% (83.8% of these hemolyzed samples collected via syringes)</td>
<td>Partial arterial catheter obstruction Syringe</td>
<td></td>
<td></td>
<td>Excessive force of aspiration Forcing blood from syringe into tube</td>
</tr>
<tr>
<td>Kennedy et al&lt;sup&gt;9&lt;/sup&gt;</td>
<td>165 patients, emergency department</td>
<td>Prospective randomized: Intravenous catheter (syringe) vs venipuncture (Vacutainer) Retrospective descriptive: Importance of diameter of catheter</td>
<td>13% (intravenous catheter) vs 3.8% (venipuncture)</td>
<td>Smaller gauge intravenous catheters (20- to 24-gauge) Intravenous catheters</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> All studies had a level of evidence of III.  
<sup>b</sup> P < .05.
Factors Associated With Hemolysis

Factors associated with hemolysis can be categorized as anatomic, equipment-related, or technical. Anatomic and physiological factors included the right hand, forearm, or antecubital space; smaller distal veins; and discharge diagnoses (respiratory, gastrointestinal, reproductive, dermatological, endocrine).1,3 In terms of location, one explanation may be that it is easier to obtain samples from the dominant side of the patient's body.1 Compared with the antecubital fossa, distal veins may also lead to more hemolysis because of their smaller diameters and thus slower flow and more resistance. These findings merit further research.

About the Authors

Margo A. Halm is a clinical nurse specialist and director of nursing research and quality at United Hospital in St Paul, Minnesota, where she leads and mentors staff in principles of clinical research and evidence-based practice. Melissa Gleaves is a staff nurse in the cardiac step-down unit at United Hospital and a graduate student in the University of Minnesota School of Nursing.

Corresponding author: Margo A. Halm, RN, PhD, CNS-BC, United Hospital - Mailstop 60316, 333 N. Smith Ave, St Paul, MN 55102 (e-mail: margohalm@gmail.com).

Recommendations Based on Current Evidence

The reported studies and manufacturers' information provide class III evidence against collecting laboratory specimens from peripheral intravenous catheters (Table 2). Although nurses may collect blood samples from peripheral intravenous catheters to reduce the number of needle sticks that patients must endure, this practice is associated with greater
hemolysis. Hemolysis can lead to delays in diagnosis and treatment while samples are collected and analyzed again, potentially affecting patients’ length of stay, especially in short-stay settings.

As a result of this evidence, blood samples should not be collected when new intravenous catheters are started or from established intravenous catheters. Some clinical exceptions include patients receiving thrombolytic agents or patients at increased risk of bleeding, or possibly in an emergency situation with limited vascular access, although hemolysis may still result and delay critical treatment. In general, blood samples for laboratory tests should be obtained via venipuncture, preferably by using Vacutainers with straight needles because such needles provide a smooth, solid inner lumen surface that is unaffected by drawing pressure, which can increase hemolysis. If blood collection into a syringe cannot be avoided, larger syringes (3-10 mL) are recommended. The antecubital fossa is the preferred site for collecting blood samples for laboratory tests because of the faster blood flow and thus decreased resistance associated with greater vessel diameter. Tourniquets should also be disengaged as soon as the flow of blood through the needle is established. Table 3 summarizes additional actions that nurses can use to prevent hemolysis.

Once blood samples have been collected, Carraro et al caution that hemolyzed specimens cannot simply be rejected. Laboratories must alert clinicians so that in vivo hemolysis can be ruled out. Therefore, clinicians can more quickly identify clinical situations that require immediate intervention, potentially improving patients’ outcomes.

Hospitals are encouraged to develop or revise standardized protocols to reflect venipuncture as the best practice for collecting blood samples, except in patients at increased risk of bleeding or patients with difficult venous access. Standardization of practice and education of staff will help eliminate the equipment and technical factors associated with greater hemolysis. However, strategies must be developed to overcome barriers to changing this practice, including personal preference and feasibility. By sharing the evidence with clinicians and emphasizing the intention of promoting quick and reliable access to essential clinical data, some barriers to practice change may become overcome.

ACKNOWLEDGMENTS
The authors acknowledge the efforts of the 2009 Nursing Research Council in critically reviewing the literature.

Table 2
Evidence grading

<table>
<thead>
<tr>
<th>Class</th>
<th>Criteria</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Definitely recommended</td>
<td>Supported by excellent evidence, with at least 1 prospective randomized controlled trial</td>
</tr>
<tr>
<td>Class IIa</td>
<td>Acceptable and useful</td>
<td>Supported by good evidence; weight of evidence and expert opinion strongly in favor</td>
</tr>
<tr>
<td>Class IIb</td>
<td>Acceptable and useful</td>
<td>Supported by fair to good evidence; weight of evidence and expert opinion not strongly in favor</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>Promising, evidence lacking, premature</td>
<td>Preliminary research stage. Evidence shows no harm but no benefit; evidence insufficient to support final class decision</td>
</tr>
</tbody>
</table>

Class Criteria Definition

- Class I: Definitely recommended
  - Supported by excellent evidence, with at least 1 prospective randomized controlled trial
  - Interventions always acceptable, safe, and effective; considered definitive standard of care

- Class IIa: Acceptable and useful
  - Supported by good evidence; weight of evidence and expert opinion strongly in favor
  - Interventions acceptable, safe, and useful; considered intervention of choice by most experts

- Class IIb: Acceptable and useful
  - Supported by fair to good evidence; weight of evidence and expert opinion not strongly in favor
  - Interventions also acceptable, safe, and useful; considered optional or alternative by most experts

- Indeterminate: Promising, evidence lacking, premature
  - Preliminary research stage. Evidence shows no harm but no benefit; evidence insufficient to support final class decision
  - Treatment of promise but limited evidence

Adapted from “Part 1: Introduction to the International Guidelines 2000 for CPR and ECC,” with permission.

Table 3
Preventing in vitro hemolysis

1. Permit antiseptic to dry completely
2. Avoid traumatic venipunctures by selecting vein of appropriate size for volume of blood being obtained; match gauge of needle with size of vein
3. Use collection tubes with reduced vacuum (ie, partial draw tubes)
4. Avoid excessive aspiration force
5. Transfer blood into evacuated tube immediately after venipuncture by using a blood transfer device
6. If syringe collection cannot be avoided, avoid pushing on plunger to increase blood flow (instead, angle syringe to permit blood to flow down side of tube via vacuum)
7. Follow guidelines from the National Committee for Clinical Laboratory Standards for the order of collecting blood samples:
   - Blood cultures
   - Coagulation (blue tube)
   - Serum (red tube)
   - Heparin (green tube)
   - EDTA (lavender tube)
   - Glycolytic inhibitor (gray tube)
8. Mix tubes according to manufacturer’s guidelines (ie, gentle mixing instead of shaking)

Abbreviation: EDTA, ethylenediaminetetraacetic acid.

* Based on data from Stankovic and Smith.

FINANCIAL DISCLOSURES
None reported.

REFERENCES
Obtaining Blood Samples From Peripheral Intravenous Catheters: Best Practice?
Margo A. Halm and Melissa Gleaves

Am J Crit Care 2009;18 474-478 10.4037/ajcc2009686
©2009 American Association of Critical-Care Nurses
Published online http://ajcc.aacnjournals.org/

Personal use only. For copyright permission information:
http://ajcc.aacnjournals.org/cgi/external_ref?link_type=PERMISSIONDIRECT

Subscription Information
http://ajcc.aacnjournals.org/subscriptions/

Information for authors
http://ajcc.aacnjournals.org/misc/ifora.xhtml

Submit a manuscript
http://www.editorialmanager.com/ajcc

Email alerts
http://ajcc.aacnjournals.org/subscriptions/etoc.xhtml