FLUSHING HEMODYNAMIC CATHETERS: WHAT DOES THE SCIENCE TELL US?

By Margo A. Halm, RN, PhD, APRN-BC, CCRN

Flushing hemodynamic catheters is essential to maintain patency and therefore ensure accuratehemodynamic measurements, arterial blood sampling, and cardiac output determinations. Patency of hemodynamic catheters has been maintained for decades in critical care settings with pressurized infusions of heparinized saline to prevent clots from forming around or within catheters. Recently, the use of heparinized saline is being questioned because of the desire to eliminate as much heparin exposure as possible and thereby minimize risks such as heparin-induced thrombocytopenia (HIT). With an estimated incidence of 1% to 3%, HIT is a rare but life-threatening condition.1-4 Although this evolution may parallel the change from using heparin to lock peripheral intravenous catheters to using saline flushes, is robust evidence available to support a similar change in practice for hemodynamic catheters? This clinical review summarizes the current scientific evidence in relation to the following question: Is the patency of hemodynamic catheters, specifically arterial catheters and pulmonary artery catheters, greater when they are flushed with heparinized saline than when they are flushed with normal saline?

Methods

The search strategy included MEDLINE and CINAHL databases, as well as hand-searching bibliographies of clinical and research articles related to flushing hemodynamic catheters. Key words and phrases included heparin, normal saline, and arterial; pulmonary artery; Swan Ganz; and hemodynamic lines/catheters. All types of evidence (nonexperimental/studies, systematic reviews, meta-analyses) were included.

Results

Seven pertinent studies were published between 1987 and 2005; of these, 5 were focused on arterial catheters5-9 and 2 were focused on arterial and pulmonary artery catheters.10,11 All studies investigated continuous flushes with either heparinized or non-heparinized solutions. Populations included peri-operative patients, as well as patients in general medical and surgical intensive care units, including patients undergoing cardiac surgery. Sample sizes in these studies were from 30 to 5037. In addition to these 7 primary studies, 2 systematic reviews1,12 and 1 meta-analysis13 were found.

Most studies involved patients with catheters in the radial and/or pulmonary artery. Standard hemodynamic setups were used, with pressure bags exerting 300 mm Hg pressure for a consistent flow rate of 3 mL/h. Most arterial studies6-9 used 20- to 22-gauge catheters; however, catheter length (2 in [5 cm]) was reported in only 2 studies.7,8 French sizes of pulmonary artery catheters were not reported. Heparinization was variable, with values of 1.0 U/mL,9,10 2.0 U/mL,8 2.5 U/mL,5 and 4.0 U/mL,6 whereas nonheparinized solutions were predominantly normal saline (though Hook et al5 used plain lactated Ringer solution). Adequacy of collateral blood flow was assessed in only half of the arterial studies.6,8,9 Randomization to treatment groups was not done in 2 studies.5,10 Patency of catheters was assessed for 72 to 96 hours or until the catheter was removed. Patency (or occlusion) was measured across studies by assessing (1) quality of arterial waveforms5-8,10 (square-wave...
testing was specified in only 2 studies7,11), (2) ease of flushing,5,6,8,10 (3) free backflow of blood,5-8,10,11 (4) radial blood flow/pressure with Doppler technology, 8,9 (5) duration of cannulation,8,9 and (6) reasons for removal.5,7,8,10 The type and frequency of the interventions used to troubleshoot dampened waveforms were recorded in 3 studies.5,6,9 Some investigators6,10 used “catheter failure,” defined as the absence of a good waveform or ability to flush or to collect a blood sample. Few studies reported reliability and validity5 of methods to assess patency, and no authors discussed interrater reliability or used quantitative scales to assess variables such as “ease of flushing.”1

Table 1 provides a summary of the evidence. Results of about half of the studies6,7,10 of arterial catheters (including the meta-analysis) indicated that heparinized solutions increase patency over time; the other studies5,8,9 showed no difference in results between types of solution. In their meta-analysis, Randolph et al13 emphasized that the minimal effective dose of heparin has not been established. Bolgiano et al14 reported no significant difference in duration of arterial patency when heparin was used at 0.25 U/mL versus 1 U/mL in adults. In addition to heparin, other variables that affect arterial patency include age (<65 years),7 sex (male),7 catheter dynamics15 (material, heparin coating,16 length >2 in or 5 cm),7 gauge, duration [longer],7 catheter location (femoral),7 issues related to the monitoring system (loose connections, cracked system components, inadequacies in flush devices or pressure infusor bags) and technique (incorrect stopcock positions, failure to monitor pressure in bag),15 and clinical variables (clotting disorders,7 presence of hematoma,7 anticoagulants, thrombolytics, or other medications affecting coagulation10). Because the arterial results are mixed, the currently available evidence is inconclusive and warrants continued research with more rigorous experimental designs incorporating measurement of variables known to influence patency of catheters.

Evidence from the mixed studies pertaining to pulmonary artery catheters suggests that heparin

### Table 1

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Design/population</th>
<th>Patency(^a) (catheter survival)</th>
<th>Level of evidence, class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arterial</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hook et al(^5)</td>
<td>50</td>
<td>Descriptive, cardiac surgical</td>
<td>0</td>
<td>IIb</td>
</tr>
<tr>
<td>Clifton et al(^6)</td>
<td>30</td>
<td>Randomized controlled trial (double-blind), adult medical intensive care unit</td>
<td>+ (86% heparin at 96 h vs 52% normal saline at 40 h)</td>
<td>Iia</td>
</tr>
<tr>
<td>American Association of Critical-Care Nurses(^7)</td>
<td>5037</td>
<td>Multisite randomized controlled trial, intensive care units (cardiac, neurological, surgical)</td>
<td>+ (90% heparin vs 79% normal saline at 72 h)</td>
<td>I</td>
</tr>
<tr>
<td>Kulkarni et al(^8)</td>
<td>108</td>
<td>Randomized controlled trial (double-blind), surgical intensive care unit</td>
<td>0 (92% heparin vs 74% normal saline at 96 h)</td>
<td>III</td>
</tr>
<tr>
<td>Tuncali et al(^9)</td>
<td>200</td>
<td>Randomized controlled trial (double-blind), perioperative</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td><strong>Mixed studies</strong></td>
<td></td>
<td></td>
<td>Arterial</td>
<td>Pulmonary artery</td>
</tr>
<tr>
<td>Zevola et al(^10)</td>
<td>226</td>
<td>Quasi-experimental, intensive care unit</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Guenther et al(^11)</td>
<td>200</td>
<td>Randomized controlled trial (double-blind), cardiac surgical</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Meta-analyses</strong></td>
<td></td>
<td></td>
<td>Arterial</td>
<td>Pulmonary artery</td>
</tr>
<tr>
<td>Randolph et al(^12)</td>
<td>26 studies (peripheral/arterial)</td>
<td>2 studies(^a) of arterial catheters</td>
<td>Relative risk 0.51 (0.42-0.61)</td>
<td>I</td>
</tr>
</tbody>
</table>

\(^a\) +, heparinized solution associated with greater potency; 0, no difference in patency between solutions.

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**About the Author**

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.

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Recommendations Based on Current Evidence

Overall, the current evidence shows that heparin improved the patency of hemodynamic catheters in about half of the randomized controlled trials. Because of concerns about the lack of uniformity of measurements of patency (and associated reliability/validity), as well as the potentially low number of pulmonary artery catheters in the mixed designs, the results of existing studies for both arterial catheters and pulmonary artery catheters are inconclusive, or of “indeterminate class” (Table 2). In 1998, Headley cautioned clinicians against changing practice standards for pulmonary artery catheters because the evidence in support of doing so is limited.

Although the critical care community is interested in minimizing heparin exposure, the existing evidence that nonheparinized solutions maintain patency is not robust. Until stronger scientific evidence becomes available, clinicians should carefully consider under what clinical circumstances heparin can safely be avoided in critically ill patients. Thunder Project investigators recommended comparing the risks of HIT with other clinical risks associated with nonpatency of catheters. For patients with heparin sensitivities, other agents (papaverine, 1.4% sodium citrate) are effective in prolonging duration of radial artery catheters. Considerations also are likely to differ depending on whether patients are anticipated to need short- or long-term hemodynamic monitoring. Leeper importantly advises tracking outcomes (eg, vessel thrombosis/catheter patency rates, incidence of HIT) if a decision is made to change practice to using nonheparinized solutions so that the quality and safety of care can be monitored.

FINANCIAL DISCLOSURES
None reported.

REFERENCES


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