A Study of Experimental Lancets for Blood Collection to Avoid Bone Infection of Infants

Samuel Meites,1 Clive R. Hamlin,2 and John R. Hayes3

We describe a study made at two pediatric centers to test experimental lancets for blood collection by skin puncture of infants' heels or fingers. Our primary goal is to decrease the hazard of osseous injury while collecting adequate blood, by using three lancet widths at a constant length of 1.0 mm. The three widths used were 1.0, 1.25, and 1.5 mm. When success at skin puncture was defined rigidly on the basis of the blood volume obtained, the data show that success was related neither to the lancets' dimensions as tested nor to the age of the child, but rather to the phlebotomist's skill and experience, which improved with time.

Additional Keyphrases: pediatric chemistry variation, source of

Past reports on the skin puncture of infants' heels revealed that the distance from skin surface to bone (calcaneus) increases with weight and age during the first 6 months of life (1–3). For this age interval, we recommended the use of 1.8-mm-long lancets for heel puncture (2, 3). Such lancets, however, are hazardous for the finger puncture of infants older than about 6 months because the distal phalanx may have a skin-surface-to-bone depth of 1.5 mm or less. When the hitherto unmeasured effect of compression during finger puncture is also considered, 1.5 mm seems indisputably excessive for the length of such a lancet.

A proposal was made4 to minimize the risk of bone puncture by testing lancets at a uniform length of 1.0 mm, but with experimental widths of 1.0, 1.25, and 1.5 mm. A primary question was Could sufficient volumes of blood be obtained with any of these lancets? We report successful use of all three sizes of lancets in two pediatric centers. The degree of success, however, apparently varies with the skill developed by the phlebotomist at each center.

Materials and Methods

Lancets. Becton Dickinson Vacutainer™ Systems (Becton Dickinson and Co., Rutherford, NJ),5 provided the experimental lancets in three sizes, 1.0 × 1.0 mm, 1.0 × 1.25 mm, and 1.0 × 1.5 mm. These were modified from the Microtainer™ Safety Flow lancet, a disposable device containing a spring-driven retracting blade, with an average thickness of about 0.10 mm, sharpened on both sides. For patients younger than 3 years, the lancet customarily used at both centers was the Neolet (Sherwood Medical, St. Louis, MO (3)), which is 1.8 mm long and about 0.89 mm wide (diameter).

Randomized distribution of lancets. The Research Information Services of Children's Hospital, Columbus, OH, established a block randomization of the lancets, with phlebotomists blinded as to size. A pair of identical lancets was taped to a questionnaire to be completed by the phlebotomist after each visit to a patient. This permitted a maximum of two skin punctures per patient with experimental lancets. Each of the two institutions' human subjects research committees approved the use of these lancets.

Subjects. Each institution studied patients selected without conscious bias, then categorized into two age groups (Table 1): heel puncture on newborn patients to ages about 6 months; finger puncture on children from ages about 6 months to 3 years. One center tested a third group of children older than 3 years.

Successful skin puncture. Phlebotomists generally perform the largest number of skin punctures for tests

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in clinical chemistry, hematology, immunology, and therapeutic drug monitoring (4). Success in skin puncture was defined in terms of volume of blood obtained. Two measures of success, particularly for statistical purposes, were used: (a) obtaining <400 μL in a single puncture (only), when the amount needed to fulfill the request was less than 400 μL (e.g., single-chemical tests, complete blood counts), and (b) obtaining at least 400 μL of blood in a single puncture (4). When two punctures were required, the volume had to exceed 400 μL or the test was considered a failure. Volumes were estimated visually from the collecting tubes used. The capacity of these tubes was randomly prechecked with accurate (Class A) pipettes. We evaluated the data by χ² analysis of the above-defined successes.

The specific questions we set out to answer were Did the lancet width at the uniform length of 1.0 mm make a difference for the three widths used on heels and fingers? Did the subject’s age determine the successful use of the lancets on heels and fingers? Was skill in using the lancets a significant factor in their successful use by phlebotomists?

Phlebotomists. At one facility, phlebotomy was initially performed by several members of a special team and by others from the chemistry and hematology sections who less frequently collected blood by skin puncture. When it became evident that the number of successes varied with the phlebotomist, all skin punctures with the experimental lancets were assigned to only two phlebotomists, who demonstrated a high rate of success. In the second center, two phlebotomists performed all of the skin punctures with the experimental lancets, regardless of their success.

### Results

The use of two measures of success showed the following: When <400 μL of blood was needed (only one puncture permitted), the median volume per patient obtained was 250 μL. About 35% of the 306 patients punctured were in this category of success. When >400 μL of blood was needed to fulfill a request, the situation fulfilled by 65% of the patients, the median volume obtained per patient per skin puncture was 486 μL. About 21% of patients required a second skin puncture to obtain the needed volume.

Table 1 shows the success rates obtained with the three lancet sizes for skin puncture of heels and fingers for the four age groups sampled at the two institutions. There was no statistically significant association between width and success, either overall (χ² = 2.53, P = 0.2815) or within any subgroups (age, puncture site, and hospital location). We adjusted for age, puncture site, and hospital location in testing the effect of width of lancet on success by use of a logistic-regression model. Only hospital location was a statistically significant factor in both finger and heel punctures.

One site had a high rate of success for finger puncture (84–100%), regardless of lancet size. For heel puncture of newborns (younger than 2 months), success at this site varied between 75% and 96% with the three lancet sizes. Heel puncture of infants older than 2 months showed success rates between 33% and 80%. The 33% value (occurring with the middle-size lancet) suggested at least two probable causes: too few heels (n = 9) were punctured in this group, or the skill of the phlebotomist was a major factor for success.

Success at the second site was about the same for heel puncture of newborns (50–66%) regardless of lancet size. For finger puncture, success varied between 48% and 68% for children younger than 3 years. The 48% value occurred with the middle-size lancet, in contrast to 92% at the first facility.

Figure 1 shows improved success of skin puncture at the two institutions as the experimental lancets were

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**Table 1. Success* at Skin Puncture According to Age, Lancet Size, and Puncture Site**

<table>
<thead>
<tr>
<th>Lancet size</th>
<th>Age (range)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total n</th>
</tr>
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<tbody>
<tr>
<td>Heels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center A</td>
<td>&lt;2 mo</td>
<td>75</td>
<td>78</td>
<td>95</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>(0.066–1.97)</td>
<td>(20)</td>
<td>(27)</td>
<td>(19)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;2 mo</td>
<td>80</td>
<td>33</td>
<td>75</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>(2.07–10.4)</td>
<td>(10)</td>
<td>(9)</td>
<td>(8)</td>
<td></td>
</tr>
<tr>
<td>Center B</td>
<td>&lt;2 mo</td>
<td>50</td>
<td>56</td>
<td>55</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>(0.033–1.84)</td>
<td>(22)</td>
<td>(25)</td>
<td>(29)</td>
<td></td>
</tr>
<tr>
<td>Fingers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center A</td>
<td>&lt;3 y</td>
<td>96</td>
<td>92</td>
<td>98</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>(0.019–2.95)</td>
<td>(25)</td>
<td>(25)</td>
<td>(42)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;3 yr</td>
<td>100</td>
<td>100</td>
<td>84</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>(3.85–31.1)</td>
<td>(28)</td>
<td>(23)</td>
<td>(19)</td>
<td></td>
</tr>
<tr>
<td>Center B</td>
<td>&lt;3 y</td>
<td>61</td>
<td>48</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>(0.48–2.91)</td>
<td>(23)</td>
<td>(20)</td>
<td>(19)</td>
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</table>

*Success as percent of punctures made.

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used over the trial period shown, without regard for lancet size and patient's age.

Discussion

The assumption was made that using a shorter lancet would reduce the chance of puncturing and infecting underlying bone. Because the sick infant may have laboratory tests repeatedly ordered daily, it is important that a puncture site not be reused, to reduce risk of infection (1). Therefore, there must be an effort to keep the width as well as the length of the lancet at a minimum, so that multiple punctures do not cross any site previously used. Because there was no apparent difference in the success rates for the three widths used, we suggest that tolerance limits for manufacture be set between 1.00 and 1.25 mm width at a constant length of 1.00 mm. Such dimensions provided a high success rate, particularly at one of the two facilities. It is possible that even narrower limits could be suitable.

The relatively high success rate found establishes the feasibility of using shorter lancets, particularly for finger puncture of infants. This is an important finding, because the fingers of infants and young children may have much less skin-surface-to-bone depth than do the heels (2).

Success at skin punctures varied with the phlebotomist's skill and with experience, as indicated in Figure 1. Those who failed tended to blame the lancet for their failure. However, the major cause of failure was related to insufficient pressure applied during skin puncture. This is the main variable between phlebotomists, if one assumes a constant mix of patients to be sampled. A lesser cause of failure may be related to the patient's physical state: e.g., flaccid skin, dehydration, debilitation, and callus formation.

The cutting area of the lancets used was about half that of the usual lancets used at both facilities. If the nerve centers for pain are evenly distributed in the skin and other areas, the pain caused by use of the experimental lancets described here should be only half that of the usual lancets, in proportion to the cutting area.

Manufacturers can improve the safety of skin puncture by providing economical lancets with cutting lengths of 1.00 mm. Such lancets provide a high rate of success with finger puncture of infants, at least to age 3 years. Although heel puncture was less successful, this may be related to skill in the use of the lancet, not to the shorter length of the lancet.

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References