Ultrasound-guided cannulation of the great saphenous vein at the ankle in infants

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Editor’s key points

- Venous access in infants is a common but challenging procedure due to their small vessel diameter.
- The use of ultrasound imaging to guide cannulation of the great saphenous vein was studied in 90 consecutive anaesthetized infants.
- Ultrasound guidance resulted in >95% success rate in this preliminary observational study.

Background. The establishment of peripheral venous access in infants is the most common invasive technique in paediatric anaesthesia. Venous puncture can be challenging due to the small size of vessels in this patient population. The present study was designed to investigate the practicability of ultrasound-guided vascular access to the great saphenous vein (GSV) at the level of the medial malleolus in infants ≤12 months.

Methods. Ninety consecutive infants ≤12 months undergoing elective surgery were included in this prospective study and divided into two age groups (0–6 and 7–12 months). After anaesthesia induction with sevoflurane, an ultrasound investigation of both GSVs at the level of the medial malleolus was performed. Subsequently, venous access in one GSV was established under direct ultrasound control. Anatomical ultrasound data and success rates of venous accesses were analysed.

Results. While not deeper relative to the skin, the GSV was significantly larger in older infants. The success rate in infants ≤6 months was 96%, whereas in older infants, the success rate was 100%. The overall success rate in all infants was 98%.

Conclusions. Ultrasound facilitates venous puncture of the GSV in the vast majority of infants ≤12 months. Direct visualization via ultrasound is a promising technique for the establishment of venous access in the GSV at the level of the medial malleolus in infants.

Keywords: children; ultrasound; vascular access

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Peripheral venous access is a prerequisite for most infants undergoing medical treatment. Establishment of venous access in the age group ≤12 months can be difficult and associated with repetitive punctures. These repetitive punctures in children can cause pain, which is associated with significant consequences such as altered pain sensitivity or behaviour modifications.

Few publications report the problem of venous access in specific paediatric age groups and populations. The current clinical standard is the puncture of visible veins at the dorsum of the hands and feet or the scalp. Veins at the dorsum of the hands or feet are very small. Scalp veins are very superficial and therefore visible in neonates and young infants, but not in older infants, and fixation of these veins is problematic. Veins at the cubital fossa are not palpable in most cases and there is the danger of inadvertent puncture of the brachial artery.

Numerous techniques to facilitate peripheral venous puncture have been described such as local warming, epidermal nitroglycerine, transillumination, and venous cutdown. Only a few reports describe the use of ultrasound for peripheral venous puncture in children, but all of them investigated older children. Ultrasound has not been evaluated for peripheral venous puncture in infants in a scientific way, although this technique is widely used for central venous lines.

Most peripheral veins in infants are too superficial and too small for direct visualization with standard ultrasound equipment. A promising alternative approach could be the great saphenous vein (GSV) at the level of the medial malleolus due to the adequate diameter and the relatively deep position relative to the skin. The present prospective, observational study was designed to evaluate the ultrasound anatomy of the GSV at the level of the medial malleolus in infants ≤12 months and to establish a technique for ultrasound-guided venous access via the GSV in this patient population.

Methods

After approval by the Ethical Committee of the Medical University of Vienna and informed parental written consent, we included 90 consecutive infants ≤12 months undergoing elective surgery with no visible veins at the dorsum of the hands or feet. In this prospective, observational study, the infants were divided into two age groups: 0–6 and 7–12 months.
**Prepuncture management**

The following procedures prior to establishment of venous access were performed in all children after standard pre-operative fastening:

(i) Time point 0 min: both medial malleolar areas prepared with EMLA cream (preoperative area).
(ii) Time point 30 min: premedication with 1 mg kg\(^{-1}\) rectal midazolam (maximum dose 15 mg) according to our clinical standard (preoperative area).
(iii) Time point 45 min: establishment of standard monitoring (Sp\(O_2\), ECG, non-invasive arterial pressure) and subsequent induction of general anaesthesia via a face mask with sevoflurane (40% \(F_{O_2}\) – \(O_2\)/air) under maintenance of spontaneous ventilation (operation theatre).
(iv) Time point 50 min (after successful induction of general anaesthesia): removal of EMLA tapes.
(v) Time point 50 min until establishment of venous access: assisted ventilation via the face mask.

**Performance of the ultrasound investigation and ultrasound measurements**

After placement of a tourniquet, a 3.3 mm jelly pad was placed on the medial malleolus. Direct ultrasound visualization of the GSV in a cross-sectional view was performed on both sides with a SonoSite M-Turbo transportable ultrasound machine and a linear 7–13 MHz ultrasound probe with a 25 mm footprint (SonoSite Inc., Bothell, WA, USA). A sterile jelly pad (3.3 mm thickness, SonarAid\(^\text{TM}\), Geistlich Pharma, Wohlen, Switzerland) was used to reduce pressure on the tissue caused by the ultrasound probe. In addition, superficial anatomical structures (such as the GSV in infants) are better visible by ultrasonography when the distance from the probe to target is increased. After visualization of the GSV, the following measurements were performed:

(i) depth of the GSV (surface of the skin to the proximal border of the vein) in mm (Fig. 1);
(ii) cross-sectional area of the GSV in mm\(^2\) (Fig. 2);
(iii) circumference of the GSV in mm (Fig. 2);
(iv) subsequently, the contralateral GSV was analysed as described above.

**Establishment of venous access**

We choose the larger GSV for initial puncture and subsequent establishment of venous access. After sterile preparation of the skin with chlorhexidine, sterile covering of the 7–13 MHz ultrasound probe (Safersonic\(^\text{TM}\), Danubiamed, Ybbs, Austria), application of a sterile ultrasound jelly pad with 3.3 mm thickness, and establishment of a tourniquet, the GSV was directly seen in a cross-sectional view (see above). After optimal visualization (GSV as a round, hypoechoic structure in the middle of the screen), the GSV was punctured under direct ultrasound guidance using an out-of-plane technique where the needle is advanced via the short axis relative to the ultrasound probe (Fig. 3). A 24 G 0.75 in. venous access (Becton Dickinson\(^\text{TM}\), NJ, USA) was used in all cases. Successful establishment of venous access was confirmed by passive blood backflow. The tourniquet was removed after the procedure and 0.5–2 ml 0.9% saline (depending on age and weight of the patient) was injected via an infusion line for subsequent confirmation of intravascular position of the cannula. A longitudinal scan of the GSV with direct visualization of the cannula was performed as an additional method of confirmation (Fig. 4). Fixation according to our clinical standard was performed after confirmation of correct intravascular position of the venous catheter.
A maximal number of three attempts for establishment of venous access in one GSV were performed. In those cases where the third attempt failed, the contralateral GSV was punctured. If successful establishment of venous access in the contralateral GSV failed, the case was counted as failure. In these cases, the external jugular vein was used as an alternative approach for venous access.

Subsequent management
After successful establishment of venous access, the anaesthetic procedure was continued depending on surgical requirements. Twenty-four hours after establishment of the venous access, we evaluated the puncture site to detect possible haematoma or local infection.

Statistical analysis
Data are presented as median (range) except where otherwise indicated. Correlations between body weight and depth/cross-sectional area of the GSV were calculated with the Pearson correlation coefficient. Analysis of anatomical data and subject characteristics was performed with the Mann–Whitney U-test. Frequency of failed punctures was analysed using Fisher’s exact test. A value of $P<0.05$ was considered statistically significant.

Results
We included 90 consecutive infants undergoing elective surgery during a period of 12 months. A flow chart according to the CONSORT statement illustrates the subject selection process (Fig. 5). Study subject characteristics are presented in Table 1. Detection of the GSV at the level of the medial malleolus via ultrasound on both sides was not possible in one case and one case was excluded from statistical analysis due to protocol violation. In one case, we could not detect a GSV on the right side, but the left GSV was detectable (98% of GSV were successfully detected in infants $\leq 12$ months).

The punctures were performed by three different experienced anaesthesiologists (L.T., P.M., H.W.). The success rate in infants $\leq 6$ months was 96% (two failures) with a median (range) of 1 (1–3) punctures per case, whereas in older infants, the success rate was 100% with a median of 1 (1–2) punctures per case ($P=0.24$ for the number of failures and $P=0.22$ for the number of attempts; Table 2). The overall success rate in all infants was 98%. While not deeper relative to the skin, the GSV was significantly larger in older infants (Table 3). We did not detect any relevant correlations between weight and morphometric data of the GSV (Table 4).

In one infant $\leq 6$ months, venous access was established in the contralateral GSV after three unsuccessful attempts on one side. In two cases, ultrasound-guided venous access failed on both GSVs and venous access was established successfully in the external jugular vein.

The investigation 24 h after venous puncture revealed no local infection and no visible haematoma.

Discussion
Ultrasound facilitates venous puncture of the GSV at the level of the medial malleoli in most infants $\leq 12$ months. Although not statistically significant, there were more failures in
infants ≤6 months due to smaller GSV. Ultrasonography is a promising technique for the establishment of venous access in the GSV in infants.

Establishment of peripheral vascular access is a prerequisite for many medical procedures in children. The exact incidence of failed attempts to establish venous access in children is unknown, but this is a well-known clinical challenge. The following techniques are used to facilitate venous puncture when no suitable veins are visible: local warming, epidermal nitroglycerin, or transillumination. Local warming and epidermal nitroglycerin cause vascular dilatation with subsequent improved visibility of veins. Transillumination techniques use cold-light for improved visibility of mainly superficial vessels. None of these techniques have been scientifically investigated in infants. In addition, local warming and epidermal nitroglycerin are time-consuming techniques and therefore not applicable in emergency situations. Transillumination techniques require a relatively dark environment and are therefore not applicable in emergency situations.

Alternative techniques such as peripheral venous cutdown and the intraosseous approach should be considered only in emergency situations due to its invasiveness. Central venous access (external jugular, internal jugular, subclavian, brachiocephalic, or femoral vein) requires particular catheter sets, is technically demanding, is associated with possible serious side-effects, and requires sedation or even general anaesthesia in infants.

Venous access via the GSV in infants is rarely described in the literature probably because of its poor direct visibility. The medical term saphenous derives from both the Greek safaina, meaning ‘manifest/to be clearly seen’ and the Arabic el safin, which means ‘hidden/concealed’. In fact, the GSV is usually clearly seen in adults, but in most cases is invisible in infants. With ultrasound, direct visualization of the GSV at the level of the medial malleoli was easy and subsequent successful insertion of a 24 G venous catheter was possible in the vast majority of infants ≤12 months. In one case, we did not detect a GSV on both sides and in one case, we failed to detect a GSV on the right side, which is probably due to the well-known variability of the GSV. Agenesis may be considered in these cases where the GSV is not visible by ultrasonography. Interestingly, we established most venous catheters in the left GSV due to minimal differences in size of the GSV.

High-resolution ultrasound is an important prerequisite to perform this technique in daily clinical practice. Despite not being directly visible in most infants, the GSV is relatively superficial for ultrasound conditions, and therefore ultrasound probes with frequency ≥13 MHz are recommended for appropriate visualization of the GSV. A jelly pad is recommended to increase the distance from the ultrasound probe to the target structure and to increase image quality.

It is obvious that veins in younger infants are smaller compared with older infants, as our measurements confirmed. Failures in establishing venous access occurred only in infants <6 months, due to the smaller size of the GSV. We did not find weight-dependent differences in the depth of

![CONSORT statement.](image)

Table 1 Subject characteristics. Data as median (range)

<table>
<thead>
<tr>
<th></th>
<th>0–6 months</th>
<th>7–12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>45</td>
<td>43</td>
</tr>
<tr>
<td>Age (months)</td>
<td>3.1 (1–6)</td>
<td>9.8 (7–12)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>5.2 (1.9–8.1)</td>
<td>8.7 (6.2–13.7)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>60 (42–75)</td>
<td>73 (60–86)</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>15.2 (10.8–19.4)</td>
<td>16.1 (9.9–25.0)</td>
</tr>
</tbody>
</table>

Table 2 Characteristics of ultrasound-guided establishment of venous accesses in the GSV. Data as median (range)

<table>
<thead>
<tr>
<th></th>
<th>0–6 months</th>
<th>7–12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puncture side</td>
<td>35 Left</td>
<td>28 Left</td>
</tr>
<tr>
<td>Number of attempts</td>
<td>1 (1–3) Left</td>
<td>1 (1–2) Left</td>
</tr>
<tr>
<td>Failures</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
the GSV. Correlations between weight and GSV measurements as illustrated in Table 4 were also weak.

This study included anaesthetized spontaneously breathing infants undergoing elective surgery, which might result in higher success rates in establishment of venous access compared with awake infants. Further studies are required to investigate the clinical efficacy of ultrasound-guided access to the GSV in infants and to compare this technique with other techniques of vascular access. The ultrasound-guided approach to the GSV is feasible and should be considered whenever ‘visible’ veins are not available.

In this context, it is important to discuss the issue of training. During the present study, well-trained paediatric anaesthesiologists with skills in ultrasound-guided vascular access and regional anaesthetic techniques performed the punctures. Consequently, particular training and the evaluation of learning curves are important prerequisites for the future establishment of this technique in the daily clinical practice of anaesthesiologists and non-anaesthesiologists.

In summary, ultrasound-guided vascular access in the GSV at the level of the medial malleolus in infants ≤12 months is a promising technique that has the potential to be used routinely in paediatric anaesthesia.

### Declaration of interest
None declared.

### Funding
Supported by departmental funds.

### Table 3 Ultrasound measurements of the GSVs. Data as median (range)

<table>
<thead>
<tr>
<th></th>
<th>0–6 months</th>
<th></th>
<th>7–12 months</th>
<th></th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>Depth (mm)</td>
<td>4.6 (1.8–9.6)</td>
<td>4.4 (1.5–9.5)</td>
<td>4.4 (1.1–7.6)</td>
<td>4.7 (1.3–10.0)</td>
<td>NS</td>
</tr>
<tr>
<td>Cross-sectional area (mm²)</td>
<td>2 (1–10)</td>
<td>2 (1–7)</td>
<td>3 (1–8)</td>
<td>3 (1–7)</td>
<td>0.02</td>
</tr>
<tr>
<td>Circumference (mm)</td>
<td>4.8 (1.4–8.2)</td>
<td>4.9 (1.8–9.4)</td>
<td>6.8 (1.9–11)</td>
<td>6.8 (1.6–11)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### Table 4 Pearson correlation coefficients between weight and morphometric parameters of the GSVs in all infants. GSV, great saphenous vein

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Weight/Depth GSV_right</td>
<td>0.28</td>
</tr>
<tr>
<td>Weight/Depth GSV_left</td>
<td>0.24</td>
</tr>
<tr>
<td>Weight/Cross-sectional area GSV_right</td>
<td>0.62</td>
</tr>
<tr>
<td>Weight/Cross-sectional area GSV_left</td>
<td>0.39</td>
</tr>
</tbody>
</table>

### References