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Local warming and insertion of peripheral venous cannulas: single blinded prospective randomised controlled trial and single blinded randomised crossover trial

Rainer Lenhardt, Tanja Seybold, Oliver Kimberger, Brigitte Stoiser, Daniel I Sessler

Abstract

Objective To determine whether local warming of the lower arm and hand facilitates peripheral venous cannulation.

Design Single blinded prospective randomised controlled trial and single blinded randomised crossover trial.

Setting Neurosurgical unit and haematology ward of university hospital.

Participants 100 neurosurgical patients and 40 patients with leukaemia who required chemotherapy.

Interventions Neurosurgical patients' hands and forearms were covered for 15 minutes with a carbon fibre heating mitt. Patients were assigned randomly to active warming at 52°C or passive insulation (heater not activated). The same warming system was used for 10 minutes in patients with leukaemia. They were assigned randomly to active warming or passive insulation on day 1 and given alternative treatment during the subsequent visit.

Main outcome measures Primary: success rate for insertion of 18 gauge cannula into vein on back of hand. Secondary: time required for successful cannulation.

Results In neurosurgical patients, it took 36 seconds (95% confidence interval 31 to 40 seconds) to insert a cannula in the active warming group and 62 (50 to 74) seconds in the passive insulation group (P=0.002). Three (6%) first attempts failed in the active warming group compared with 14 (28%) in the passive insulation group (P=0.008). The crossover study in patients with leukaemia showed that insertion time was reduced by 20 seconds (8 to 32, P=0.013) with active warming and that failure rates at first attempt were 6% with warming and 30% with passive insulation (P<0.001).

Conclusions Local warming facilitates the insertion of peripheral venous cannulas, reducing both time and number of attempts required. This may decrease the time staff spend inserting cannulas, reduce supply costs, and improve patient satisfaction.

Introduction

Insertion of intravenous cannulas is probably the most commonly performed invasive medical procedure.
On the basis of the data from neurosurgical patients we calculated that we would need 40 patients in a crossover trial to provide an 80% chance of identifying a significant difference between the groups with a two tailed \( \alpha \) of 0.05. We carried out this part of the study in patients with leukaemia who were scheduled for at least two sessions of chemotherapy, at least one week apart. In these patients the mean weight was 71 (SD 19) kg, the mean height was 169 (SD 8) cm, and the mean age was 63 (SD 14) years; 20 were men.

**Protocol**

A carbon fibre warming mitt (Thermamed, Bad Oeynhausen, Germany), consisting of a carbon fibre resistive heating element covered with cloth, was placed over the left hand and forearm of the neurosurgical patients in the preoperative area. The mitt is connected by a wire to a solid state controller. It has been approved by the German Technische Überprüfungsanstalt TÜF (technical monitoring agency) and has CE certification (safety certificate from the European Union), confirmed by Thermamed. However, it has not been approved by the US Food and Drug Administration and is not commercially available in the rest of Europe. There is no shock hazard associated with this device as it is powered by 12 volts DC. The mitt is closed on three sides, leaving the fourth side open for insertion of the cannula.

Participating neurosurgical patients were randomly assigned to passive warming (mitt not heated) or to active warming (mitt warmed to 52°C). Group assignment was determined by computer generated codes, thus ensuring an equal distribution of participants. Codes were kept in sequentially numbered opaque envelopes until just before use. The mitt was removed after 15 minutes and patients were asked to clench their left hands. A tourniquet was then applied 10 cm proximal to the wrist and the patient relaxed his or her hand. A resident in haematology, blinded to treatment, then attempted to insert an 18 gauge cannula into a vein on the back of the left hand. The nurse anaesthetist was not otherwise involved in the study and was not told that local warming was the basis for our hypothesis.

In both groups of patients we ended the study after the first successful attempt at cannulation. Subsequent management was at the discretion of the provider.

**Measurements**

We measured the time from the start of searching for an appropriate vein (after the tourniquet was applied) to successful insertion of the cannula. Successful cannulation was confirmed by administration of a crystalloid solution without any signs of infiltration. Likewise, we recorded the number of failed first attempts. We examined the treated hand and arm for burns or skin irritation after the cannula had been inserted. We asked the neurosurgical patients if they had experienced any thermal discomfort related to the treatment.

**Analysis**

We analysed the results after all the data were collected. An audit confirmed integrity of the randomisation process and that the computer generated codes were used in sequential order. We compared data from the warmed and unwarmed neurosurgical patients with unpaired two tailed \( t \) or \( \chi^2 \) tests. We compared results in the warmed and unwarmed patients with leukaemia with paired two tailed \( t \) or McNemar tests. We have presented data as means (SD); \( P<0.05 \) identified significant differences.

**Results**

**Neurosurgical patients**

All enrolled patients completed the study. Characteristics of patients were comparable in the actively and passively warmed groups. Before warming there was a
significant but clinically unimportant difference in hand temperatures. However, forearm and fingertip temperatures and vein scoring were comparable.

Fifteen minutes of warming significantly increased vein scores, thermal comfort, and skin temperatures (table 1). The success rate for insertion of the intravenous cannula was 94% (44/50) in the active warming group versus 72% (36/50) in the passive insulation group (P=0.008). Cannula insertion took about half as long with active warming (36 seconds (95% confidence interval 31 to 40 seconds) versus 62 seconds (50 to 74 seconds), table 1). We did not observe any skin irritation nor did any patients report any discomfort.

Patients with leukaemia
We enrolled 42 patients with leukaemia. Two failed to return for their subsequent course of chemotherapy or declined to participate further in the study; both had initially been assigned to passive insulation. Thus 40 patients completed both study days. Only these patients were included in the data analysis.

Ten minutes of active warming significantly increased vein scores, thermal comfort, and skin temperatures (table 2). On the day patients were assigned to active warming, the success rate for insertion of the cannula in these patients was 95% versus 73% in the passive warming group (P<0.001). The time elapsing from beginning to search for an appropriate vein until successful cannulation was 20 seconds (8 to 32) shorter with active warming than with passive insulation (P=0.02, table 2). We did not observe any skin irritation.

Discussion
Percutaneous intravenous cannulation is usually rapid, but because the procedure is so common even modest reductions in the time required could be clinically important. Various procedures improve venous visibility and thus, presumably, facilitate insertion of intravenous cannulas. For example, vein prominence is usually increased by gently tapping over the site, applying proximal tourniquets, or asking patients to clench and relax their hands. Venous engorgement may be improved by having arm hanging down. These measures are used routinely but often fail to augment vein size sufficiently.

In our patients local warming increased vein size. This increase was clinically important in that it halved insertion time in both groups. Equally importantly, the fraction of unsuccessful attempts was reduced fivefold. Warming with topical application of 4% nitroglycerine ointment also decreases the number of cannulation attempts and facilitates insertion. However, topical nitroglycerine is systemically active and requires considerably longer to produce venodilation than local heating.

Local heating increased hand temperature and produced a local warm sensation. However, skin temperature averaged only about 40.5°C, even after 15 minutes of warming. This temperature is not associated with tissue injury as long as it is not combined with prolonged pressure. None of the volunteers reported discomfort, and none experienced cutaneous irritation. We therefore conclude that local warming is safe as well as effective. In the patients with leukaemia we were allowed to warm patients’ hands for only 10 minutes and thus skin temperatures were lower. However, fewer attempts were needed for successful cannula insertion in the warmed group. Although we were testing different groups of patients it seems likely that warming patients’ hands and arms for just 10 minutes will increase the rate of successful first attempts.

Possible bias
Arteriovenous shunt blood flow and hand venous tone is not normally under conscious control. Furthermore, patients were not informed that we were testing warming (as opposed to passive insulation or some other aspect of the device). It thus seems unlikely that our results were biased by responses under the patients’ control.

Table 1 Details of neurosurgical patients in trial of effect of warming on cannulation. Figures are mean (SD) unless stated otherwise

<table>
<thead>
<tr>
<th></th>
<th>Active warming (n=50)</th>
<th>Passive insulation (n=50)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>21</td>
<td>26</td>
<td>0.42</td>
</tr>
<tr>
<td>Age (years)</td>
<td>58 (15)</td>
<td>50 (14)</td>
<td>0.06*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74 (13)</td>
<td>72 (13)</td>
<td>0.32*</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170 (8)</td>
<td>170 (9)</td>
<td>0.72*</td>
</tr>
</tbody>
</table>

Vein score† >3 before treatment:

<table>
<thead>
<tr>
<th></th>
<th>No (% of patients)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal comfort before treatment (VAS)</td>
<td>12 (24)</td>
<td>12 (24)</td>
<td></td>
</tr>
<tr>
<td>Fingertip temperature before treatment (°C)</td>
<td>40.5 (3.1)</td>
<td>30.9 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Hand temperature before treatment (°C)</td>
<td>32.7 (2.5)</td>
<td>31.9 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Forearm temperature before treatment (°C)</td>
<td>33 (1.6)</td>
<td>32.7 (1.1)</td>
<td></td>
</tr>
</tbody>
</table>

Vein score† >3 after treatment:

<table>
<thead>
<tr>
<th></th>
<th>No (% of patients)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal comfort after treatment (VAS)</td>
<td>58 (8)</td>
<td>46 (10)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Fingertip temperature after treatment (°C)</td>
<td>40.5 (2.1)</td>
<td>33.0 (3.6)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Hand temperature after treatment (°C)</td>
<td>40.6 (2.3)</td>
<td>33.3 (1.6)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Forearm temperature after treatment (°C)</td>
<td>38.0 (1.9)</td>
<td>34.5 (3.9)</td>
<td>0.03*</td>
</tr>
</tbody>
</table>

Mean (95% CI) time to successful insertion (s) 36 (31 to 40) 62 (50 to 47) 0.002*†

Table 2 Differences between cannulation with active warming and passive insulation in patients with leukaemia in crossover trial. Figures are means (95% confidence intervals) or number of patients

<table>
<thead>
<tr>
<th>Differences within patients (n=40)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with vein score* &gt;3 with active warming but not with passive insulation</td>
<td>12</td>
</tr>
<tr>
<td>Patients with vein score* &gt;3 with passive insulation but not with active warming</td>
<td>0</td>
</tr>
<tr>
<td>Patients with same vein score* grouping regardless of treatment</td>
<td>28</td>
</tr>
<tr>
<td>Difference in fingertip temperature (°C)</td>
<td>4.7 (3.7 to 5.8)</td>
</tr>
<tr>
<td>Difference in hand temperature (°C)</td>
<td>5.3 (4.5 to 6.5)</td>
</tr>
<tr>
<td>Difference in forearm temperature (°C)</td>
<td>3.3 (2.5 to 4.9)</td>
</tr>
<tr>
<td>Patients with failed first attempts for passive insulation but success with active warming</td>
<td>10</td>
</tr>
<tr>
<td>Patients with failed first attempts for active warming but success with passive insulation</td>
<td>1</td>
</tr>
<tr>
<td>Patients with same results regardless of treatment</td>
<td>29</td>
</tr>
<tr>
<td>Difference in time to successful insertion (s)</td>
<td>20 (8 to 32)</td>
</tr>
</tbody>
</table>

*See table 1 for definition of vein scoring.†McNemar test.‡Paired t test.
The nurse anaesthetist and residents who attempted to insert the intravenous cannulas were blinded to treatment and were also not told that we were testing warming. Obviously, they could feel that in some patients the hands were warmed, and to this extent our blinding was unavoidably incomplete. However, we consider that the observed differences in cannula insertion time and success rates result from local warming rather than investigator bias.

Contributors: RL initiated and coordinated the formulation of the primary study hypothesis, designed the protocol, analysed the data, and wrote the paper. TS participated in data collection and documentation of the neurosurgical patients. OK and BS participated in data collection and documentation of the haematological patients. DIS participated in the design of the study protocol and discussed core ideas and interpretation of the findings.

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Competing interests: DIS is a consultant for ThermaMed.


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