Negative Pressure Suction During Blood Sampling May Reduce the Difference in Self-Monitoring of Blood Glucose Results Between Fingertip Pricking and Forearm Pricking

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Abbreviations: ITT, insulin tolerance test; OGTT, oral glucose tolerance test; SMBG, self-monitoring of blood glucose.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.
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Self-monitoring of blood glucose (SMBG) at alternate puncture sites, such as the forearm, gives users an alternative to fingertip puncture, which can be painful. However, it has been reported that blood glucose values obtained at alternate sites are different from those obtained at the fingertip. We aimed to examine whether SMBG results obtained at the forearm are clinically identical to those at the fingertip and whether blood sampling technique by negative pressure suction could reduce the fingertip-to-forearm differences.

RESEARCH DESIGN AND METHODS — Five male volunteers were recruited. A 75-g oral glucose tolerance test (OGTT) identified four individuals with impaired glucose tolerance and one with diabetes. Subject age, HbA1c, fasting venous plasma glucose, and BMI were 50.4 ± 2.1 years, 5.2 ± 0.3%, 95 ± 10 mg/dl, and 23.1 ± 0.6 kg/m², respectively (means ± SE). Each participant was trained assistants from the fingertip and forearm at 0, 30, 60, 90, and 120 min (0 in ITT) in OGTT and at 10, 20, 30, 40, 50, and 60 min in ITT by using the FreeStyle system (FreeStyle Kissei Meter and Free-Style Lancing Device; Kissei Pharmaceutical, Tokyo, Japan). Skin rubbings were performed before the puncture in accordance with the procedure manual. Since the required blood sample volume was small (0.3 μl), negative pressure suction to obtain a blood sample in this system was unnecessary. Additional blood collection with negative pressure suction, using the Multi-Lancet for Forearm & Fingertip Lancet Device (Arkray, Kyoto, Japan), was also conducted at the forearm.

OGTT and insulin tolerance test (ITT) were continuously performed in the fasting state. OGTT was performed using the usual methods; blood glucose levels were monitored at 0, 30, 60, 90, and 120 min after the ingestion of a 75-g glucose solution. After the blood collection at 120 min of the OGTT, ITT was started by intravenous administration of insulin at 0.1 unit/1 kg body wt. The blood samplings in ITT were made every 10 min until hypoglycemia appeared (<60 mg/dl of venous glucose level) or 60 min from the beginning of ITT. Capillary blood samples were collected in parallel by two trained assistants from the fingertip and forearm at 0, 30, 60, 90, and 120 min (0 in ITT) in OGTT and at 10, 20, 30, 40, 50, and 60 min in ITT by using the FreeStyle system (FreeStyle Kissei Meter and Free-Style Lancing Device; Kissei Pharmaceutical, Tokyo, Japan). Skin rubbings were performed before the puncture in accordance with the procedure manual. Since the required blood sample volume was small (0.3 μl), negative pressure suction to obtain a blood sample in this system was unnecessary. Additional blood collection with negative pressure suction, using the Multi-Lancet for Forearm & Fingertip Lancet Device (Arkray, Kyoto, Japan), was also conducted at the forearm.

RESULTS — At baseline, the capillary blood glucose levels at the fingertip, forearm without suction, and forearm with suction were 104.8 ± 9.5, 95.4 ± 8.7, and 107.4 ± 9.9 mg/dl, respectively. During the blood glucose–increasing phase, the blood glucose values at the forearm without suction were lower than those at the fingertip. At minute 30 of the OGTT, the capillary blood glucose value at the forearm without suction was significantly lower than that at the fingertip (146.2 ± 14.3 vs. 173.4 ± 14.7 mg/dl, P = 0.023) but the forearm blood glucose value with suction was not different from the fingertip value (171.0 ± 14.0 vs. 173.4 ± 14.7 mg/dl, P = 0.366). During the blood glucose–decreasing phase in the ITT, the blood glucose values at the forearm with and without suction were higher than those at the fingertip. At minute 20 of the ITT, the forearm blood glucose values without and with suction were significantly higher than the fingertip value (165.4 ± 26.0 and 147.2 ± 32.3 vs. 126.6 ± 34.1 mg/dl, P = 0.013 and P = 0.043, respectively). At minute 30 of the ITT, the forearm blood glucose values without and with suction were also significantly higher than the fingertip blood glucose values (137.8 ± 24.7 and 121.2 ± 28.6 vs. 99.2 ± 29.1 mg/dl, P = 0.002 and P = 0.011, respectively). There was also a significant difference between the forearm blood glucose values without and with suction at 30 min (P = 0.049). The fingertip-to-forearm blood glucose differences (forearm values minus finger-
tip values) determined by the two sampling methods, without and with negative pressure suction, are shown in Fig. 1. The blood glucose differences measured without negative pressure suction were almost twice those measured with suction. There were two cases where the glucose values at the forearm without suction stayed within the normal range (96 and 97 mg/dl), although those at the fingertip exhibited hypoglycemic values (41 and 52 mg/dl).

CONCLUSIONS — Since Jungheim and Koschinsky (1,2) reported their findings about a risky delay of hypoglycemia detection by glucose monitoring at the arm site, it has been stated that during rapid blood glucose change, SMBG values obtained at alternate sites of diabetic patients lag behind the fingertip values (3,4). The current study confirmed that SMBG values measured at the forearm were significantly delayed compared with fingertip values, even in impaired glucose tolerant patients, and that noxious fingertip-to-forearm blood glucose differences (<60 mg/dl at fingertip and >90 mg/dl at forearm) could arise in some cases. This phenomenon is a clinically important problem that should be solved by devising SMBG methods that involve small amounts of pain. Localized rubbing of the skin before a pricking procedure has been recommended to avoid the unfavorable finger-to-alternate site glucose differences. However, in this study, considerable fingertip-to-forearm glucose differences were observed in spite of skin rubbings. It has also been reported that there is considerable interindividual variability in the effect of rubbing the skin and that the effect is uncertain (2).

We demonstrated that the fingertip-to-forearm blood glucose difference was reduced by half using the blood collection procedure that collects 2.0 μl by negative pressure suction. Two mechanisms may be considered in this favorable effect: 1) mechanical stimulation increased blood flow in the pricking site and 2) the proportion of the intercellular fluid in the sample decreased as the volume of blood increased with suction. It has been reported that during rapid glucose change, the change of glucose levels in intercellular fluid is delayed in relation to the blood (5).

We conclude that it is effective to use negative pressure suction, which increases the volume of blood samples, to reduce the fingertip-to-alternate site blood glucose differences.

References