Alternate-Site Testing Is Reliable in Children and Adolescents With Type 1 Diabetes, Except at the Forearm for Hypoglycemia Detection

NADINE LUCIDARME, MD[1]
CORINNE ALBERTI, MD[2]
ISABELLE ZACCARIA, MD[2]
EMMANUEL CLAUDE, MD[3]
NADIA TUBIANA-RUFI, MD[1]

Self-monitoring of blood glucose (SMBG) is crucial to the management of type 1 diabetes (1,2). Until recently, SMBG relied only on capillary blood sampling by fingerstick (a source of pain) and other forms of patient discomfort likely to diminish adherence to SMBG. After approval of alternate-site testing (AST), clinical studies found differences across measurement sites (3) in diabetic adults experiencing rapid blood glucose variations (4). Although pediatric patients with type 1 diabetes may be particularly likely to benefit from new methods that decrease pain and other burdens associated with frequent SMBG, alternate-site SMBG in this age-group has not been fully validated.

The objectives of this study were to determine whether blood glucose measured at alternate testing sites (thenar and forearm) in diabetic children showed clinically significant differences compared with fingertip values and to evaluate patient satisfaction with AST.

RESEARCH DESIGN AND METHODS

We included 29 children (aged 5–17 years) who had type 1 diabetes of at least 1 year's duration and performed SMBG three or more times a day. The ethics committee of the St. Louis Hospital, Paris VII University, approved the study.

For each SMBG over two consecutive randomized 8-day periods, each patient used two sampling sites: the fingertip and either the thenar or the forearm. SMBG was done three times a day before meals and once a day after the evening meal, using the FreeStyle Papillon glucose meter. The patients were not instructed to rub the site before sampling, since the benefits of rubbing remain controversial (4,5).

At the end of this 16-day period, patient preference for fingertip or AST was recorded. During a second study period, which lasted 1 month, the patients were free to choose between fingertip and AST following recommendations for adults at the time of the study. At study completion, each patient was asked this question: "In your opinion, is alternate-site testing a progress?"

Data were analyzed using a mixed-effects linear regression model (SAS version 8.02; SAS Institute, Cary, NC). Clinical accuracy was assessed using Clarke error grid analysis (6–8).

RESULTS

Table 1 reports the differences in blood glucose between the fingertip and alternate sites for the preprandial, postprandial, and hypoglycemic episode samples, taking intraindividual correlations into account. The differences were minimal (near zero) for all comparisons, except for the fingertip versus the forearm for samples taken during hypoglycemia (≤60 mg/dl).

The clinical relevance of correlations was analyzed using Clarke error grids (Table 1). The 95% limits of agreement showed no differences in Clarke grid distributions for preprandial or postprandial comparisons. Differences were found across sites for hypoglycemia samples: 20.4% of forearm values were in region D, whereas 100% of thenar values were in region A.

After 16 days, 66% of patients reported a preference for AST over the fingertip, citing easier sampling in larger zones and decreased pain, whereas habit was the main reason for fingertip preference. At study completion, 73% of patients overall perceived AST to be a progress.

CONCLUSIONS

This study is the first evaluation of AST conducted in children and under real-life conditions. We found that prepandial SMBG data in pediatric patients were consistent with reported data from adults at the same sampling sites (3,4,9). Postprandial SMBG values in our pediatric population showed no significant differences between the fingertip and the forearm or thenar, whereas studies in adults found that fingertip postprandial values differed from forearm values but not from thenar values. It should be noted that published studies usually evaluated these differences in individuals experiencing rapid blood glucose variations during oral glucose tolerance testing (4,10). Our study was conducted in a very different situation, namely, routine SMBG. Clarke error grid analysis confirmed the agreement for postprandial values by establishing that alternate-site results were clinically rele-

From the [1]Department of Endocrinology, Robert Debre Teaching Hospital, AP-HP, Paris, France; the [2]Center of Clinical Epidemiology, Robert Debre Teaching Hospital, AP-HP, Paris, France; and [3]Ypsomed, Paris, France.

Address correspondence and reprint requests to Dr. Nadine Lucidarme, Department of Endocrinology, Robert Debre Teaching Hospital, 75019 Paris, France. E-mail: nadine.lucidarme@jvr.ap-hop-paris.fr.

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Abbreviations: AST, alternate-site testing; 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.

Table 1—*Differences in blood glucose values between the fingertip and alternate sites and Clarke error grid analysis in preprandial, postprandial, and hypoglycemic episode samples, with the 95% limits of agreement*

Number of paired BGDs	Fingertip BGD (mg/dl)	Sites	Blood glucose differences (mg/dl)	Clarke error grid	
				Zones A + B*	Zones D + E
Preprandial					
$n = 695$	190 ± 97	F, T	−3.5 ± 32 (−66.0, 59.1)	98.9%	0.4%
$n = 675$	187 ± 96	F, FA	−3.2 ± 37 (−76.4, 70.1)	97.9%	1.8%
Postprandial					
$n = 120$	212.7 ± 82	F, T	−0.9 ± 35 (−69.0, 67.1)	99.2%	0.8%
$n = 117$	224.7 ± 7	F, FA	0.8 ± 32 (−62.8, 64.4)	97.4%	2.6%
Hypoglycemia ≤60 mg/dl					
$n = 54$	51.3 ± 6.7	F, T	−1.0 ± 5 (−10.9, 8.9)	100%	0%
$n = 49$	50.5 ± 8.3	F, FA	−11.5 ± 31 (−73.0, 49.9)	79.6%	20.4%

Data are means ± SD or means ± SD (95% limits of agreement) unless otherwise indicated. *Clinically acceptable zones. BGD, blood glucose determination; F, fingertip; FA, forearm; T, thenar.

vant. During hypoglycemic episodes, however, we found major differences between the fingertip and forearm. Because forearm values are not reliable during hypoglycemic episodes, forearm sampling is not appropriate in this situation or in patients with hypoglycemia unawareness (11). In contrast, thenar sampling is reliable.

Whether AST improves patient compliance with SMBG, as demonstrated in a study in adults (12), remains to be determined in pediatric studies conducted over longer periods, especially in adolescents. The implications of our study go beyond conventional SMBG, since they are also relevant to new techniques for continuous blood glucose measurement with glucose sensors, which is prone to the AST-like phenomenon (13).

In conclusion, SMBG at alternate sites (thenar and forearm) was clinically reliable before and after meals in type 1 diabetic children, who perceived this alternative as a progress in their daily management. Therefore, SMBG at alternate sites can be recommended with the caveat that forearm sampling should not be used in children with symptoms of hypoglycemia or in specific conditions carrying a high risk of hypoglycemia. These recommendations should be incorporated into educational programs for children with diabetes.

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