BLOOD GLUCOSE LEVELS IN CHILDREN DURING SURGERY

B. G. WATSON

SUMMARY

Changes in blood glucose levels in children during surgery have been found not to follow the pattern reported in adults, no relationship being found between the "stressfulness" of the operation and the rate of rise of blood glucose concentration. In 10 per cent of the children studied the blood glucose level immediately after induction was within the hypoglycaemic range.

There has been no report of the changes which occur in the blood sugar in children in response to different types of surgery. A recent report by Clarke (1970), showed that in adults a progressive rise in blood sugar occurred during surgery, which was more marked during abdominal than during body surface surgery, and was linear with time.

METHOD

Eighty patients aged between 22 months and 15 years were studied. They were premedicated with oral trimperazine (Vallergan Forte), 1.7 mg/kg to a maximum of 30 mg, 3 hours preoperatively, and intramuscular morphine 0.25 mg/kg with atropine 0.02 mg/kg 1 hour preoperatively. Anaesthesia was induced with thiopentone 4 mg/kg followed by tubocurarine 0.8 mg/kg or pancuronium 0.13 mg/kg and, following intubation, pulmonary ventilation was controlled with nitrous oxide and oxygen. Patients having major procedures were given intravenous infusions of Hartmann's solution 5 ml/kg/hr during surgery. No patient was known to suffer from any metabolic disease.

The operations performed were: 1 hiatus hernia repair; 23 laparotomies; 1 thoracotomy; 25 minor plastic procedures; 2 cleft lip and palate repairs; 2 revisions of Spitz-Holter valve catheters; an elevation of a depressed fracture of the skull; 18 squint and ptosis corrections; 4 orchiopexies; and a biopsy of an osteochondroma of the femur. Local infiltrations of adrenaline were used in three plastic cases.

Two ml samples of venous blood were taken from each patient into fluoride bottles, one after induction of anaesthesia but before surgery had begun, and one at a variable time later. Samples were taken from the arm without an intravenous infusion. Glucose concentrations were measured by the technique of Morley, Dawson and Marks (1968). This is a glucose oxidase method with an accuracy of ±5%. The normal fasting range is between 40 and 100 mg/100 ml. In infants over 6 months a level of 40 mg/100 ml or below is regarded as hypoglycaemic.

RESULTS

The age distribution of the patients is shown in figure 1.

The mean of all the preoperative blood glucose levels was 60 mg/100 ml. The mean of the second samples taken between 20 and 110 min later was 68 mg/100 ml, a highly significant difference (P<0.001; table I). In none of the patients given adrenaline to aid surgery did a rise in blood glucose occur.

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The 80 cases were subdivided into a group of 25 having major operations (laparotomy, thoracotomy), and 55 having lesser procedures. The groups were not identical as regards either age or the duration of preoperative starvation (tables II and III), though neither of these factors significantly affected the rate of rise of blood glucose which occurred. This rate was not significantly different in the two groups (table IV).

TABLE I. Mean values of first and second samples (glucose mg/100 ml blood ± 1 SD)

<table>
<thead>
<tr>
<th></th>
<th>Mean of first samples</th>
<th>Mean of second samples</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60.3 ± 21</td>
<td>68.5 ± 46</td>
<td>P &lt; 0.001</td>
</tr>
</tbody>
</table>

TABLE II. Mean ages of patients (years).

| Patients having major operations | 10.8 (range 3-16) |
| Patients having minor operations | 7.7 (range 2-14)  |

TABLE III. Duration of pre-operative starvation (hours).

| Patients having major operations | 12.5 (range 7-18) |
| Patients having minor operations | 9.5 (range 3-17)  |

TABLE IV. Rate of rise of blood glucose (mg/min ± 1 SD).

<table>
<thead>
<tr>
<th>No. of cases</th>
<th>Rate of rise</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major operations</td>
<td>25</td>
<td>0.53 ± 0.47</td>
</tr>
<tr>
<td>Minor operations</td>
<td>55</td>
<td>0.59 ± 0.76</td>
</tr>
</tbody>
</table>

The distribution of the initial blood glucose levels is shown in figure 2. Eight cases were within the hypoglycaemic range. They were younger (mean age 4.25 ± 3.3 yr) than the others (mean age 6.45 ± 3.7 yr) but the difference was not significant (P > 0.1). There was no association between the occurrence of hypoglycaemia and the duration of preoperative fasting: the mean duration of fasting in the hypoglycaemic and non-hypoglycaemic group was identical at 10 ± hours, though older children tended to have been starved longer. Nor was there any difference between these two groups as regards their rate of rise of blood glucose during surgery (table V). No patient gave any reason for believing that he was hypoglycaemic at the time of induction. Details of the hypoglycaemic patients are given in table VI.

The choice of relaxant did not effect the rate of rise of blood glucose (table VII).

TABLE V. Rate of rise of blood glucose in patients initially hypoglycaemic, and in those not hypoglycaemic (mg/min ± 1 SD).

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>Mean rate of rise</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initially hypoglycaemic</td>
<td>8</td>
<td>0.64 ± 0.7</td>
<td>n.s.</td>
</tr>
<tr>
<td>Not hypoglycaemic</td>
<td>72</td>
<td>0.56 ± 1.04</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

TABLE VII. Influence of relaxant on rate of rise of blood glucose (mg/min ± 1 SD).

<table>
<thead>
<tr>
<th>Relaxant</th>
<th>No. of cases</th>
<th>Mean rate of rise</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancuronium</td>
<td>25</td>
<td>0.49 ± 1.9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Tubocurarine</td>
<td>53</td>
<td>0.63 ± 0.45</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

DISCUSSION

In adults the hyperglycaemic response to surgery is related to the duration and stressfulness of the operation. Clarke (1970) measuring total reducing substances rather than glucose found a highly significant difference between body surface and intra-abdominal surgery, using groups of 20 and 30 patients respectively. The intra-abdominal group showed a highly significant increase over the body surface group at 30, 45 and 60 min after the initial sample, though not at 15 min (P < 0.001 in each case). The mean rises were of 10 mg/100 ml at 60 min in the body surface group and 38 mg/100 ml in the intra-abdominal group. Anaesthesia consisted of thiopentone, tubocurarine, and nitrous oxide. When propanidid was used the rises were higher, and thoracic surgery was found to have an intermediate effect, suggesting that the
Table VI. Details of children who were hypoglycaemic before surgery.

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation</th>
<th>Age (yr)</th>
<th>Blood glucose (mg/100 ml)</th>
<th>Time starved (hr)</th>
<th>Interval samples between (min)</th>
<th>Relaxant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Squint</td>
<td>12</td>
<td>Initial: 28, Final: 90</td>
<td>8</td>
<td>20</td>
<td>Pancuronium</td>
</tr>
<tr>
<td>2</td>
<td>Excision naevus</td>
<td>4</td>
<td>Initial: 40, Final: 40</td>
<td>9</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pyeloplasty</td>
<td>3</td>
<td>Initial: 38, Final: 58</td>
<td>14</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Elevation of fractured skull</td>
<td>5</td>
<td>Initial: 30, Final: 30</td>
<td>13</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Thoracotomy</td>
<td>3</td>
<td>Initial: 30, Final: 45</td>
<td>8</td>
<td>30</td>
<td>Tubocurarine</td>
</tr>
<tr>
<td>6</td>
<td>Cleft palate</td>
<td>2 5/12</td>
<td>Initial: 40, Final: 55</td>
<td>6</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Excision of bald patch of scalp</td>
<td>3</td>
<td>Initial: 30, Final: 30</td>
<td>8</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ureteric implantation into colon</td>
<td>15</td>
<td>Initial: 25, Final: 30</td>
<td>18</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

Case No. 2 had a local infiltration of 2 ml lignocaine 0.5% with 1:80,000 adrenaline
Case No. 8 was said to have a poor appetite.

greater "stressfulness" of abdominal surgery may be due to traction on the peritoneum and mesentery.

It is unlikely that this difference was related to a rise in reducing substances other than glucose.

In the present study, there was a wide scatter in the results, but no difference was seen between the major and minor procedures. Premedication and anaesthesia were light. This would have tended to exaggerate any difference which exists, if this is due to an increased sensory input, as the response has been shown to be smaller with deep anaesthesia (Clarke, 1970).

Attention was drawn initially to the problem of hypoglycaemia by a child who was sweating and complaining of headache before induction, and was found to be hypoglycaemic. None of the 80 children subsequently studied showed any signs of hypoglycaemia, though this is unlikely under 5 years of age. An incidence of 10% of hypoglycaemia in children about to undergo surgery is unacceptably high, even though none showed a further fall during operation. Shortening of the period of preoperative starvation would be expected to reduce the incidence despite the absence of statistical evidence of an association. The danger of regurgitation of gastric content at induction outweighs the beneficial effect of a high glucose content of the last preoperative feed. Vallergan Forte contains 65 g of sucrose per 100 ml, and is strongly hypertonic. The maximum dose of this was limited to 5 ml.

Routine rapid estimation of blood glucose after induction by testing with Dextrostix (Ames) would be of help, and urine testing for ketones before the patient comes to theatre might detect those at risk.

There can be no doubt that intravenous infusions during paediatric surgery should contain glucose. A suitable fluid is 5% dextrose in half-strength Ringer lactate. Although there was no evidence that the hypoglycaemia was harmful in any of the children studied, the results justify further study of the metabolic response of children to surgery.

Acknowledgements
I am very grateful to Mr J. Ireland and the staff of the Biochemistry Department of Alder Hey Children's Hospital, who performed the estimations, and to Dr G. H. Bush for his help and encouragement.

References

Taux de la glycémie chez l'enfant durant la chirurgie

SOMMAIRE
On a observé que les modifications de la glycémie chez l'enfant durant la chirurgie ne sont pas similaires à celles observées chez l'adulte et on ne trouva aucun rapport avec le degré de stress provoqué par l'opération et le taux d'augmentation de la glycémie. La glycémie augmenta chez dix pourcent des enfants étudiés aussi tôt que l'induction atteignait le niveau hypoglycéémique.
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NIVELES DE LA GLUCOSA SANGUÍNEA EN NIÑOS DURANTE OPERACIONES QUIRÚRGICAS

ZUSAMMENFASSUNG
Es wurde beobachtet, dass sich die Veränderungen der Blutglucosewerte bei Kindern während einer Operation anders verhalten, als es für Erwachsene beschrieben wurde; zwischen der "Schwere des Stress" einer Operation und der Rate des Blutzuckeranstieges konnte keine Beziehung gefunden werden. Bei 10% der untersuchten Kinder bewegte sich der Blutzuckerspiegel unmittelbar nach der Einleitung der Narkose im hypoglykämischen Bereich.

RESUMEN
Ha sido observado que los cambios en los niveles de la glucosa sanguínea en niños durante operaciones quirúrgicas no siguen el patrón comunicado para los adultos, no encontrándose ninguna relación entre el "stress" de la operación y el aumento de la concentración de glucosa en la sangre. En el 10 por ciento de los niños estudiados el nivel de la glucosa sanguínea inmediatamente después de la inducción estaba dentro de los límites de la hipoglicemia.

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