METABOLIC RESPONSE TO ANAESTHESIA AND UPPER ABDOMINAL SURGERY IN NIGERIANS: CHANGES IN PLASMA CORTISOL, INSULIN AND BLOOD SUGAR

J. A. O. MAGBAGBEOLA AND B. KWAKU ADADEVOH

SUMMARY

In 10 Nigerian patients undergoing upper abdominal surgery the plasma cortisol concentration was slightly decreased after premedication with pethidine and atropine, and during anaesthesia without surgery. There was a small increase during surgery. None of these changes was statistically significant. There was a significant increase in the postoperative period however. Premedication caused a slight increase in blood sugar which remained steady during anaesthesia. There was a significant increase after 30 and 60 min of surgery, with a peak value at 60 min after operation. There were no significant changes in the mean values of plasma insulin concentration throughout the period of study.

In a recent review of the world literature on anaesthesia and carbohydrate metabolism, Clarke (1973) concluded that Europeans and Japanese show a significant hyperglycaemic response to trauma under all types of anaesthesia, though it is less marked than the response of Jamaicans or Indians. This conclusion was based on the studies by Keating (1958) on Jamaicans, Cullingford (1966) on Indians, Clarke (1968 and 1970) on Europeans, and Oyama and Takazawa (1971a). Earlier reports by Barnicot and Wolffson (1952); Monnet, Baylet, and Reynaud (1952); Stirling and Keating (1958); and Phillips and Cohen (1959) indicated that the adrenal glands in Africans are less active than those of Europeans. However, recent studies of basal plasma cortisol concentrations in East and West Africans (Leonard, 1965; Leonard and Stanfield, 1965; Adadevoh, 1968) and of plasma cortisol responses to exogenous ACTH, insulin-induced hypoglycaemia, and acute non-fatal haemorrhage (Adadevoh, 1968) seem to contradict the earlier impression.

The adrenocortical response of the West African to anaesthesia and surgery has been little studied although inadequate adrenocortical reserve resulting in circulatory insufficiency during and after surgery has been suggested (Keating, 1956). Foulkes-Crabbe, Abiodun and Johnson (1971) observed an increase of about 150% in plasma cortisol concentration after 60 min of surgery of differing type.

The present study was undertaken to investigate some metabolic effects associated with anaesthesia using a thiopentone-nitrous oxide-oxygen-muscle relaxant technique for upper abdominal surgery. Changes in plasma cortisol, insulin and blood sugar concentrations in adult Nigerians were measured and compared with results obtained from previously published observations.

METHODS

Ten Nigerian patients, of physical status 1 and 2 (ASA) and between the ages of 20 and 68 years, were studied. All were undergoing elective upper abdominal operations (vagotomy and either pyloroplasty or gastrojejunostomy); all the operations commenced at 09.00 hours. None of the patients showed evidence of endocrine, renal, hepatic or metabolic disorders. All were starved for at least 12 hours before surgery.

The patients were premedicated with atropine 0.6 mg and pethidine 100 mg given i.m. at 08.00 hours. Anaesthesia was induced with thiopentone 5 mg/kg, which was followed by pancuronium 0.1 mg/kg body weight. Anaesthesia was maintained with nitrous oxide 3.5 l./min with oxygen 1.5 l./min administered through an endotracheal tube using a semiclosed circle absorption system. Supplementary doses of pethidine 20 mg were given i.v. approximately at 30-min intervals, and pancuronium 1–2 mg was given when indicated. Ventilation
was controlled with a Cape-Waine ventilator with a minute volume of 10 L/min. The residual effect of pancuronium was antagonized with neostigmine 2.5–3.5 mg preceded by atropine 1.2 mg.

Blood loss from each patient was minimal and none required blood transfusion. During surgery each patient received between 100 and 150 ml of Ringer lactate solution.

The pulse rate and arterial pressure were measured at 10-min intervals using a pulse monitor (Cotel Keating) and a pneumatic cuff.

Nine samples of venous blood were collected via a 19-gauge butterfly needle in the antecubital vein from each patient: (1) 08.00 hours—before premedication; (2) 09.00 hours—before induction of anaesthesia; (3) after 15 min of anaesthesia; (4) after 30 min of anaesthesia; (5) after 45 min of anaesthesia; (6) after 10 min of anaesthesia and surgery; (7) after 30 min of anaesthesia and surgery; (8) after 60 min of anaesthesia and surgery and (9) 60 min after the end of anaesthesia and surgery. Ten millilitres of blood for estimation of plasma cortisol concentration was collected into lithium heparin bottles, 2 ml for blood sugar estimation into fluoride oxalate bottles, and 5 ml for estimation of plasma insulin into untreated bottles. All samples were received at the laboratory coded.

Plasma cortisol was estimated using the fluorimetric method of Mattingly (1962) as previously described by Adadevoh (1968), plasma insulin by radioimmunoassay as previously described by Adadevoh and Lukambi (1972), and the blood sugar by the glucose-oxidase method of Huggett and Nixon (1957) with appropriate quality control (College of American Pathologists quality evaluation programme).

RESULTS

Table I shows details of the patients and the duration of surgery.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
<th>Sex</th>
<th>Duration of surgery (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35</td>
<td>55</td>
<td>F</td>
<td>80</td>
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<td>2</td>
<td>37</td>
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<td>F</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>86</td>
<td>F</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>72</td>
<td>M</td>
<td>85</td>
</tr>
<tr>
<td>5</td>
<td>46</td>
<td>70</td>
<td>M</td>
<td>110</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>71</td>
<td>M</td>
<td>75</td>
</tr>
<tr>
<td>7</td>
<td>48</td>
<td>60</td>
<td>M</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>45</td>
<td>61</td>
<td>M</td>
<td>95</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>65</td>
<td>M</td>
<td>105</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>51</td>
<td>F</td>
<td>70</td>
</tr>
</tbody>
</table>

Mean 43.2 62.6 88.5
SEM 4.1 4.2 4.8

Table II and figure 1 show the plasma cortisol concentrations at the different stages of observation. The initial mean value before premedication was 20.8 μg/100 ml. There was a decrease to 15.1 μg/100 ml 60 min after premedication; this change was not statistically significant. The mean value was 13.9, 15.6, and 12.3 μg/100 ml during, respectively, 15, 30 and 45 min of anaesthesia without surgery. These changes were not statistically significant when compared with the initial value. During surgery the mean values were 23.6 and 32.2 μg/100 ml after 30 and 60 min of surgery. The increases compared with the control were not significant. At 60 min after operation, the mean value was 38.2 μg/100 ml (t=2.89; P<0.02).

The blood sugar values are given in table III and figure 2. The mean value was 67.9 mg/100 ml initially, and 73.4 mg/100 ml at 60 min after premedication. This increase was not statistically significant. The mean value remained steady during anaesthesia without surgery but increased to 71.6, 83.1, and 97.8 mg/100 ml after 10, 30 and 60 min of surgery. The increases compared with the control were not significant. At 60 min after operation, the mean value was 38.2 μg/100 ml (t=2.89; P<0.02).

n.s. = Not statistically significant.


**Table III. Mean blood sugar concentration before, during and after anaesthesia and surgery (mg/100 ml).**

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Before premed.</th>
<th>Before induction</th>
<th>During anaesthesia</th>
<th>During surgery</th>
<th>After operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>67.9</td>
<td>73.4</td>
<td>10</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>30</td>
<td>66.7</td>
<td>65.6</td>
<td>69.8</td>
<td>71.6</td>
<td>9</td>
</tr>
<tr>
<td>45</td>
<td>4.68</td>
<td>5.36</td>
<td>5.46</td>
<td>7.42</td>
<td>9</td>
</tr>
<tr>
<td>60</td>
<td>3.61</td>
<td>n.s.</td>
<td>n.s.</td>
<td>&lt;0.05</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

n.s. = Not statistically significant.

**DISCUSSION**

These studies on Nigerian patients show that during anaesthesia with thiopentone-nitrous oxide-pancuronium supplemented with pethidine, no significant changes occur in plasma cortisol, insulin, and blood sugar. During upper abdominal surgery, whilst no statistically significant changes in plasma cortisol occurred after 30 and 60 min, significant increases in blood sugar were observed at these times. Significant increases in both plasma cortisol and blood sugar after operation were recorded. There were only minor changes in plasma insulin concentration both during and after surgery.

The normal plasma cortisol values in Nigerians have been estimated at the University College Hospital, Ibadan, to range from 6 to 30 µg/100 ml between 08.00 and 12.00 hours. In the present study, all the blood samples were collected before 12.00 hours. Premedication with atropine and pethidine given 1 hour before induction of anaesthesia was found in this study to cause a small decrease in plasma cortisol (table II). This finding is at variance with the conclusion by Oyama et al.
TABLE IV. Mean plasma insulin concentration before, during and after anaesthesia and surgery (µU/ml).

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Before premed.</th>
<th>Before induction</th>
<th>During anaesthesia</th>
<th>During surgery</th>
<th>After operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Mean</td>
<td>15.7</td>
<td>15.2</td>
<td>14.0</td>
<td>13.6</td>
<td>13.0</td>
</tr>
<tr>
<td>Mean diff. from initial value</td>
<td>-0.5</td>
<td>-1.7</td>
<td>-2.1</td>
<td>-2.7</td>
<td>-1.9</td>
</tr>
<tr>
<td>SEM</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.6</td>
<td>1.9</td>
</tr>
<tr>
<td>P</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s. = Not statistically significant.

![Graph of plasma insulin concentration](image)

Fig. 3. Plasma insulin concentration (mean ± SEM) before, during and after surgery and anaesthesia.

(1969) and the opinion of Oyama (1973) that pethidine does not inhibit adreno-cortical stimulation caused by preoperative emotional stress. Oyama and his colleagues (1969) compared the plasma cortisol levels at 08.30 hours on the day of operation in patients who were given pethidine, 1 hour before induction of anaesthesia, with the same group of patients without pethidine at a similar time on the day preceding surgery. It is possible that the initial value of plasma cortisol on the day of operation and before injection of pethidine at a similar time on the day preceding surgery. It is possible that the initial value of plasma cortisol on the day of operation and before injection of pethidine at a similar time on the day preceding surgery was higher than the level on the day preceding operation as a result of emotion or stress. In the present study the plasma cortisol was estimated on the day of operation before premedication. Our findings on the effect of anaesthesia without surgery accord with those of Oyama et al. (1969) and Clarke, Johnston and Sheridan (1970).

After 30 and 60 min of anaesthesia and surgery there were mean increases of 2.8 and 11.4 µg/100 ml which when compared with the increases recorded by Clarke, Johnston and Sheridan (1970) on a group of patients who had intra-abdominal surgery are very small. Similar small mean increases of 3.0 and 6.7 µg/100 ml were recorded by Oyama et al. (1969) at 30 and 60 min during different types of surgical procedures. The results of a previous study by Foulkes-Crabbe, Abiodun and Johnson (1971) of Nigerians after 1 hour of varying surgical procedures accord with our findings even though the surgical procedures in the present study have been limited to the upper abdomen.

There have been several studies on the effect of different anaesthetic agents and surgical procedures on blood sugar concentration and the various reports have been reviewed by Clarke (1973). However, a few observations on the results of the present study merit discussion. There was a statistically non-significant increase in blood sugar 1 hour after premedication with pethidine and atropine. The literature information on the effects of pethidine on blood sugar is sparse although studies on animals showed increases associated with the injection of pethidine (Larson, 1949; Sollmann, 1957). Jaffe (1965), showed that morphine causes a hyperglycaemia response in man. The mean increases in blood sugar concentration after 30 and 60 min of surgery in the present study are less than the values observed by Keating (1955) in Jamaicans, and Cullingford (1966) in Indians. Our results seem to be comparable with those of Cullingford (1966) and Clarke (1970) on European patients who had similar types of anaesthesia and surgery. Oyama, Takiguchi and Kudo (1971) recorded in Japanese patients larger mean increases of 46.0, 53.8 and 76.7 µg/100 ml after 15, 30 and 60 min of surgery respectively. Thus, whilst Nigerians exhibit significant hyperglycaemia in response to surgery, this is not more marked than in the European, Japanese, Jamaican, and Indian patients.
The absence of change in plasma insulin concentrations have been observed in previous studies of this type (Allison, Tomlin and Chamberlain, 1969; Clarke, Johnston and Sherridan, 1970; Oyama, Takiguchi and Kudo, 1971).

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REFERENCES