ELECTROCARDIOGRAPHY DURING POSTERIOR FOSSA OPERATIONS

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SUMMARY

Continuous electrocardiography was performed during eighty operations on the posterior fossa of the skull and fifty-seven other neurosurgical operations, all in the sitting position. There was little difference between the two groups in the incidence of arrhythmia before operation and during the surgical approach; more serious irregularities were almost entirely confined to periods when the surgeon was operating in the vicinity of the pons, the medulla, and the roots of the fifth, ninth and tenth cranial nerves. Severe arrhythmias may indicate or be the cause of medullary failure in this position and may also give an early warning of air embolism. Therefore continuous electrocardiography is valuable provided that its limitations are understood.

During the last five years continuous electrocardiography has been carried out during operation in a series of eighty consecutive posterior fossa operations and, for comparison, in forty-three cases of cervical laminectomy and in fourteen cases of trigeminal root section by the lateral extradural approach. All patients were operated on in the sitting position, but for trigeminal root section a table was used instead of a chair and the patient's legs were horizontal. The average age was less in the posterior fossa group as it included thirty-seven children.

The posterior fossa cases were premedicated with atropine only. The remainder were given a small dose of morphine sulphate, 11 mg or less, in addition to the atropine. Anaesthesia was induced with thiopentone in all patients with the exception of two infants in whom open ether was used. It was maintained with nitrous oxide, oxygen, and trichloroethylene using a T-piece technique. One child, whose cardiac rhythm remained normal throughout, received a small amount of halothane. Electrocardiographic recording was started as soon as the patient had been placed in the sitting position.

RESULTS

The results obtained are summarized in table I. Group A refers to the posterior fossa cases, group B to the remainder. All tracings illustrated have been taken from lead 2. P-wave abnormalities include absent or inverted P-waves and atrial extrasystoles, but not alterations in the height of the P-wave or in the length of the P-R interval. Runs of ventricular extrasystoles refer to bursts of three or more consecutive extrasystoles. Severe bradycardia was defined as a heart rate of less than 50 beats a minute or of less than 60 beats a minute when the rate had dropped suddenly by more than 40 a minute. A swinging pulse rate refers to cases in which the pulse rate was rapidly and repeatedly altering by more than 40 beats a minute. In five instances this was due to an intermittent sinus bradycardia interrupting a sinus tachycardia and in the remaining three to recurrent bursts of alternating ventricular extrasystoles in which the abnormal beat was too weak to be felt at the wrist.

Cardiac irregularities occurred in 51 per cent of group A and in 43 per cent of group B. Three patients in group B had isolated ventricular extrasystoles before, as well as during, operation. Another (case 2) had a pre-operative tracing that suggested either myocardial ischaemia or pericarditis. Severe bradycardia, runs of consecutive ventricular extrasystoles, and a swinging pulse rate were more common in group A and, with two exceptions, they only occurred while surgical manoeuvres were being carried out in the vicinity of the pons, the medulla, or the roots of the fifth, ninth, and tenth cranial nerves. The exceptions
**TABLE I**

<table>
<thead>
<tr>
<th></th>
<th>Before operation</th>
<th>During surgical approach</th>
<th>Inside skull or dura mater</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>P-wave abnormalities</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Isolated or alternating ventricular extrasystoles</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Runs of consecutive ventricular extrasystoles</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Severe bradycardia</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Idioventricular rhythm</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Swinging pulse rate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Group A refers to posterior fossa explorations.
Group B refers to cervical laminectomies and trigeminal root sections.

were the case with the abnormal pre-operative tracing already mentioned (case 2) and a youth with a cerebellar medulloblastoma in whom the bradycardia that occurred shortly after the surgical incision was associated with a sudden and severe fall in blood pressure. All six cases of acoustic neuroma showed an arrhythmia while the tumour was being removed, four developing severe bradycardia and two developing runs of ventricular extrasystoles. The two instances of bradycardia in group B occurred during trigeminal root section while the root was being defined and divided.

It was noticeable that the cardiac and respiratory centres appeared to be affected independently in spite of their close anatomical proximity. Apnoea could occur without any electrocardiographic changes and an arrhythmia, even of a pronounced vagal type, could appear without any alteration in the respiratory rhythm.

**CASE REPORTS**

Two cases are described in detail.

**Case No. 1.**
A drowsy and cachectic man, aged 49, had a carcinoma of the bronchus with a secondary deposit in the cerebellum. His systolic blood pressure fell from 145 to 115 mm Hg while the occipital bone was being removed. A prolonged run of ventricular extrasystoles amounting to a ventricular tachycardia ensued, the pulse becoming first irregular and then impalpable and the blood pressure falling to an unrecordable level. Unfortunately it was impossible for the surgeon to stop at this moment and, after a few minutes of various forms of persistent ventricular arrhythmia, the heartbeats became infrequent as well as irregular. Methylamphetamine 5 mg given intravenously produced a slight but transient improvement of the ventricular complexes without having any effect on the blood pressure. An intravenous injection of 1 ml of 1/10,000 noradrenaline had no effect on either, and all ventricular activity ceased while the wound was being closed (fig. 1). The postmortem examination showed medullary and left uncal pressure cones.

![Fatal ventricular arrhythmia during posterior fossa exploration (case 1).](image1)

**Case No. 2.**
A woman, aged 43, had a cervical spondylosis. A routine pre-operative electrocardiogram, which was unfortunately not available until after the operation, showed elevation of the S-T segment and inversion of the T-wave, suggesting either myocardial ischaemia or pericarditis. Isolated ventricular extrasystoles...
Ventricular arrhythmia during cervical laminectomy (case 2). appeared while the laminae were being removed and were followed by a bigeminal rhythm with a radial pulse rate of 40 beats a minute. There was a sudden fall of blood pressure accompanied by multifocal ventricular extrasystoles and a completely irregular pulse. This was followed by an alternating left bundle branch block. Methylamphetamine 3 mg was given intravenously and the systolic pressure rose from 60 to 160 mm Hg, the rhythm reverting to alternating ventricular extrasystoles. Intravenous procaine 2 ml of a 1 per cent solution, produced a reversion to normal rhythm with a persistent tachycardia of 160 beats a minute (fig. 2). At no time was the typical millwheel murmur of air embolism heard on auscultation of the chest.

At the end of the operation the patient was just responding to her name, but her level of consciousness did not improve on return to the ward. She had an aphasia and a weakness of the right face and arm, and these, together with her level of consciousness, improved slowly over the next three days. An electrocardiogram taken seven days after the operation showed that the S-T segment had returned to normal and that the inversion of the T-wave was less pronounced.

DISCUSSION

Basically the development of cardiac arrhythmia during anaesthesia depends on two factors, a stimulus of some kind and the sensitivity of the heart to that stimulus. The stimulus may be a direct one applied to the heart itself or a reflex one produced by direct or indirect stimulation of the brain stem (figs. 3, 4). The sensitivity of the heart to these stimuli may be increased by anoxia, carbon dioxide retention, and anaesthetic agents (Sloan, 1950; Burstein, Lo Pinto, and Newman, 1950; Young et al., 1951; Jacoby et al., 1955; Bourne, 1956).

Trichloroethylene has been accused of causing many forms of cardiac arrhythmia (Barnes and Ives, 1944; Hunter, 1944; Östlere, 1953; Johnstone, 1956; Norris and Stuart, 1957). Some of these observations were made in the early days of its use when the limitations of this agent were
not understood, and both depth of anaesthesia and carbon dioxide retention may have played a part (Faulconer and Bickford, 1960; Johnstone, 1951a). Similar arrhythmias have been experienced with all inhalation anaesthetics (Maher et al., 1934; Kurtz, Bennett and Shapiro, 1936; Johnstone, 1951b; Johnstone, 1955; Hunter, 1956; Cannard et al., 1960; Johnstone and Nisbet, 1961). In this series the concentrations of trichloroethylene used were minimal, but, although a T-piece technique with an adequate gas flow was employed, one cannot rule out the possibility of respiratory depression against which the T-piece would not offer any protection.

In animal experiments arrhythmias have been induced by stimulation of various parts of the central nervous system. Brow, Long and Beattie (1930) and Allen (1931) produced ventricular extrasystoles in cats and rabbits by stimulating the hypothalamus. Dikshit (1934) did the same by stimulating the central end of the cut vagus nerve. Korteweg, Boeles and Ten Cate, 1957, when stimulating the hypothalamus and the corpora quadrigemina, found that extrasystoles occurred as frequently when stimulation ceased as during it. This has recently been confirmed (Manning and De V. Cotten, 1962). Miller and Bowman (1916) produced cardiac arrest by stimulation of the dorsal nucleus of the vagus in the floor of the fourth ventricle and Van Leeuwen (1945) produced nodal and ventricular rhythms, including multifocal ventricular extrasystoles, by stimulating the brain between the corpora quadrigemina and the posterior portions of the cerebellum. In another study arrhythmias induced by diencephalic stimulation disappeared on cooling and reappeared on warming the vagus nerves (Manning and De V. Cotten, 1962). It is known that the sino-auricular node is controlled mainly by the right vagus nerve and the auriculo-ventricular node by the left (Best and Taylor, 1950). There is some evidence that cardiac arrhythmias result from the interplay of both vagal and sympathetic influences; whereas electrical stimulation of the right vagus or of the right stellate ganglion affected heart rate only, simultaneous excitation of both caused cardiac arrhythmias (Manning and De V. Cotten, 1962).

In the clinical field, Howland and Papper (1952) have stated that cardiac irregularities during intracranial operations can be brought about by stimulation of the dura mater and the uncal gyrus, and by sudden changes in the intracranial pressure. Bradycardia may be caused by stimulation of the floor of the fourth ventricle or the trigeminal nerve (fig. 5), and Lahey and Ruzicka (1950) recorded a case of cardiac arrest that occurred during trigeminal root section, though unfortunately the approach used was not mentioned.
Sudden collapse during a posterior fossa operation can obviously be brought about by surgical interference with the cardiac and vasomotor centres in the brain stem or the ninth and tenth nerves in their vicinity, either by direct stimulation, by the withdrawal of direct stimulation, or possibly by an interference with their blood supply. In the sitting position, any arrhythmia that leads to cardiac inefficiency may produce medullary anoxia and the one fatality in this series (fig. 1) was attributed to this mechanism, which could have been initiated by a change in the intracranial pressure and might have been averted by a prompt return of the patient to a horizontal position. A vaso-vagal reflex or a severe haemorrhage could have the same result. A large air embolus may cause immediate cardiac failure while a small one may produce an arrhythmia, which can again lead to medullary anoxia. The incidence of air embolism in these operations is uncertain, but the characteristic millwheel murmur has not been heard, although the heart was auscultated whenever a severe arrhythmia or an unexplained fall of blood pressure occurred.

It is difficult to find surgical records of fatal collapse during posterior fossa operations. In 2,192 operations by various surgeons, many of them admittedly performed under local analgesia, it is only mentioned once and by Revilla (Sachs, 1931; Cushing, 1932; Verbeek, 1946; Revilla, 1947; Spitz, Shenkin and Grant, 1947; Bailly, 1948; Lampe and MacIntyre, 1949; Davis et al., 1950; Horrax, 1950; Jefferson, 1950; Northfield, 1950; Olivecrona, 1950; Pennybacker and Cairns, 1950; Ingraham and Matson, 1954; Poole and Pava, 1957; Gol and McKissock, 1959). The complications listed are respiratory failure, shock and haemorrhage and the operation was occasionally abandoned for these reasons. Only Poole and Pava mention cardiac irregularities in their book on acoustic neuromata.

Anaesthetic records give a different picture. Briggs and Beecher (1956) when analyzing cases of cardiac arrest during operation at one hospital over a thirty-year period, excluded all neurosurgical procedures because of the relationship of the surgery to the vital centres. In a mixed series of 200 cases of cardiac arrest in which neurosurgical cases were included, thirteen occurred during operations on the posterior fossa. Of these, seven were attributed to medullary failure, one to air embolism, one to a convulsion and one to haemorrhage. All were fatal (Gillespie, 1944; Trent and Gaster, 1944; West, 1954; Bergner, 1955; Dornette and Orth, 1956).

Continuous electrocardiography is valuable during these operations if used as a non-specific early warning system. A normal tracing is no guarantee of an adequate circulation and normal or relatively normal tracings have been obtained during severe hypotension and even after clinical death (Sabwala, Gunter and Dillon, 1957). It is, however, a continuous visual aid that can be watched while attending to circulatory and respiratory emergencies, and may give an early indication of the occurrence of air embolism. It will also differentiate between a true bradycardia and alternating ventricular extrasystoles in which the abnormal beat is too weak to be felt at the wrist. Nodal rhythms, isolated ventricular extrasystoles, and bigeminal rhythms are usually of little significance, but should lead to an immediate check of the patient's blood pressure and general condition. Runs of consecutive ventricular extrasystoles and
severe bradycardia, with or without idioventricular rhythm, are more dangerous and the surgeon should be warned immediately. Withdrawal of the causal stimulus is better than an attempt to treat a variable arrhythmia with the appropriate drug.

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L’ÉLECTROCARDIOGRAPHIE CONTINUELLE PENDANT LES INTERVENTIONS DANS LA FOSSA OCCIPITALIS

SOMMAIRE

L’auteur fit enregistrer des électrocardiographies continues pendant 80 opérations dans la fosse postérieure du crâne et pendant 57 autres interventions neurochirurgicales — les unes comme les autres exécutées en position assise des patients. Entre ces deux groupes il y a une différence entre l’incidence d’arythmies avant l’intervention et celles constatées pendant la première partie des interventions chirurgicales était peu importante, — les irrégularités plus sérieuses étant présqu’entièrement limitées aux moments pendant lesquels l’opérateur intervint à proximité de la pons, de la medulla et des “racines” des cinquième, neuvième et dixième nerfs crâniens. Des arythmies graves indiquent ou constituent des moments où il est possible que l’embolie d’air. Pour ces raisons l’électrocardiographie continue est précieuse dans les catégories citées d’interventions, — pourvu que l’on comprenne ses limites naturelles.

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DAS ELEKTROKARDIOGRAMM WÄHREND OPERATIONEN IM BEREICH DER HINTEREN SCHÄDELGRUBE

ZUSAMMENFASSUNG