ANÆSTHESIA FOR CEREBRAL ANGIOGRAPHY*

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HISTORY

Cerebral angiography entails the radiographic demonstration of the cerebral arteries and veins following the intra-arterial injection of a contrast medium.

In 1927 Egas Moniz (1934), Professor of Neurology at Lisbon, introduced a 25 per cent solution of sodium iodide into the carotid artery. This procedure unfortunately resulted in a high incidence of fits despite pre-operative phenobarbitone. By 1931 he had performed 300 arteriograms when he abandoned sodium iodide and began using thorotrast, a 25 per cent suspension of thorium dioxide. Thorotrast was non-irritating and gave good contrast on subsequent films. It was, however, permanently radioactive and Northfield and Russell (1937) demonstrated histological retention of thorotrast in the walls of cerebral vessels. It was also stored in the reticulo-endothelial system, and in some cases could be demonstrated in the liver and spleen months after introduction into the circulation. MacMahon et al. (1947) reported a case of endothelial-celled sarcoma of the liver following an injection of 75 ml. of thorotrast twelve years previously. Furthermore, by using a Geiger Müller counter, radioactivity was shown to be present in the liver at post-mortem. For these reasons thorotrast is now very rarely used in angiography.

Gross (1940) in America first reported using Diodone

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FIG. 1
X-ray film showing a normal lateral angiogram. The carotid siphon and the anterior and middle cerebral vessels are filled with diodone.

FIG. 2
X-ray film showing a normal antero-posterior angiogram. The branches of the anterior cerebral artery are in the mid-line while the middle cerebral branches are seen fanning out over the lateral aspect of the hemisphere.
Fig. 3
X-ray film showing a lateral angiogram with a frontal lobe angioma. A large branch of the anterior cerebral artery is seen running to supply it.

Fig. 4
X-ray film showing an antero-posterior angiogram with a "berry" aneurysm of the Circle of Willis.
FIG. 5

The patient's head rests on the cassette holder, the X-ray tube being in position for the antero-posterior view.
FIG. 6
The needle is about to be inserted into the neck after being filled with saline. The X-ray tube is in position for the lateral view.
compounds, which consist of a form of iodine in which the characteristic pharmacological activity of this substance is suppressed and which are stable in aqueous solution and speedily excreted from the body by the kidneys. Because the resultant films were of lower contrast to those when thorotrast was employed a concentrated solution of Diodone 70 per cent was used. Unfortunately complications followed, and fits, thrombosis and prolonged loss of consciousness were reported (Dyke, 1940). These are, however, not often seen when a weaker solution is used.

Broman and Olssen (1948) in experiments in dogs with Diodone, found altered permeability of the blood-vessels of the brain which may give rise to oedema, depending on the concentration used and the time the solution is in contact with the brain. Thus, slowing of the cerebral circulation may increase the number of complications. He recommended using a concentration less than 50 per cent and in this series a 40 per cent solution has been used.

In 1927 Egas Moniz (Wickbom, 1948) tried on four occasions to inject the carotid artery by the percutaneous route but failed and resorted to the open method of exposing the carotid artery and injecting under direct vision. In 1929 Lomas and Myerson began treating general paralysis of the insane by injecting arsphenamine into the carotid artery and in 1936 they applied this technique to cerebral angiography (Loman and Myerson, 1936). The method did not become established until 1944 when Engeset in Norway developed the percutaneous route and Lindgren (1947) in Britain firmly established it as routine procedure.

DETAILS OF CASES UNDER REVIEW

In the last 18 months, 169 angiograms have been performed on 102 patients. The presenting symptoms are summarized in Table I.
TABLE I

<table>
<thead>
<tr>
<th>Presenting Symptoms</th>
<th>No. of Cases</th>
<th>No. of Pathological Angiograms</th>
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<tbody>
<tr>
<td>Paralysis</td>
<td>33</td>
<td>17</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>Subarachnoid haemorrhage</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Disorders of vision</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Aphasia</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Headache</td>
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<td>0</td>
</tr>
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<td>Total</td>
<td>102</td>
<td>38</td>
</tr>
</tbody>
</table>

The 38 pathological angiograms are analysed in Table II.

TABLE II

<table>
<thead>
<tr>
<th></th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombosis artery</td>
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<tr>
<td>Aneurysm</td>
<td>7</td>
</tr>
<tr>
<td>Angioma</td>
<td>6</td>
</tr>
<tr>
<td>Glioma</td>
<td>7</td>
</tr>
<tr>
<td>Meningioma</td>
<td>1</td>
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<tr>
<td>Secondary carcinoma</td>
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<tr>
<td>Undifferentiated tumour</td>
<td>4</td>
</tr>
<tr>
<td>Post traumatic cyst</td>
<td>1</td>
</tr>
<tr>
<td>Cerebral abscess</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
</tr>
</tbody>
</table>

Figures 1 and 2 show normal lateral and antero-posterior angiograms. Figure 3 is of a frontal lobe angioma, and figure 4 shows a berry aneurysm of the Circle of Willis.

ANGIOGRAPHIC TECHNIQUE

We have performed angiograms on 102 patients and but for two children the percutaneous method has been used. A description of the technique used is necessary for an appreciation of the anaesthetic difficulties.

The patients are placed on the X-ray table with their backs supported on pillows and their heads resting on the cassette holder (figs. 5 and 6). This special holder allows the rapid serial exposure of three films each for the antero-posterior and lateral views. The leaded rubber screen
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Cut to fit round the patient's neck is to protect the radiologist's hands from direct radiation. Care must be taken to avoid pressure sores from direct contact with the sharp vertical edge of the cassette holder which often presses on the patient's shoulder.

Two radiologists are present, one to puncture the artery and the other to inject the contrast solution. The common carotid artery is palpated one inch above and one inch lateral to the sternoclavicular junction where the artery is comparatively superficial in the carotid triangle covered by skin, platysma and deep cervical fascia. In some patients where there is low division of the carotid artery the internal carotid may be entered and the region of the carotid sinus is not infrequently needlel. If local anaesthesia is employed the patient experiences considerable discomfort and choking sensation from pressure with the fingers fixing the artery prior to puncture, unless this is done gently.

A No. 18 gauge lumbar puncture needle 4 inches long is used for arterial puncture and is connected to a length of pressure tubing with intervening glass tubing to act as an inspection window. To the far end of the tubing is attached another adaptor into which a nozzle of a syringe can be fitted. A 20 ml. syringe containing physiological saline is attached and the tube and needle are filled with solution: this is important in order to avoid air embolism. Once the skin is pierced, the saline syringe is disconnected and the artery sought. This may take anything from seconds to many minutes. When the artery is entered, blood is seen flowing back through the inspection window. The syringe is then re-attached and saline slowly injected until all is ready for exposing the films. No obstruction to injection should be present, for if clot formation should occur, the rapid injection of contrast medium would dislodge the clot and a cerebral embolus would result. If the
saline flows freely the needle is still in the artery. A 20 ml. syringe containing 40 per cent Diodone is attached and injection as fast as possible begun. The first film is exposed after 8 ml. is injected, the second two seconds later, and the third two seconds after that. If done under local anaesthesia, the patient feels a burning sensation in the distribution of the vessel injected and unless he co-operates by remaining perfectly still, the pictures will be blurred. The syringe containing the saline is re-attached and the needle kept patent by slow injection of saline whilst the X-ray tube is rotated for the antero-posterior view. If the needle is still in the artery the same routine of injection is repeated. Approximately 32 ml. of the solution is used for each complete angiogram. In some patients a bilateral angiogram is necessary and a minimum time of forty-five minutes is required. However, this is often exceeded in technically awkward cases. After withdrawal of the needle, pressure is maintained on the neck at the site of entry into the artery to minimize haematoma formation.

ANAESTHETIC TECHNIQUE

Local anaesthesia with procaine after premedication with Nembutal, Omnopon and Scopolamine is recommended in the literature (Friel, 1950). There is, however, scanty reference to the use of general anaesthesia for cerebral angiograms. Curtis (1950) of Oxford states that ‘if the patient is under light general anaesthesia there is often a sudden move of the head at the moment which corresponds to the exposure of the films and that it is better to work with a conscious patient’. However, he says later that with young children and with unco-operative or mentally deranged patients general anaesthesia is necessary, but no details are given.

Rait-Smith (1949) stated that ‘carotid arteriography
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should not be attempted under nitrous oxide and oxygen anaesthesia alone, for there must be no risk of the patient coughing”.

From the above description of the technique of cerebral angiography it is apparent that the following requirements must be satisfied if a general anaesthetic is to be used:

1. The patient must be protected from pressure on the carotid sinus, which can produce a fall of blood-pressure as may be seen in figure 7.

2. The patient must remain still during the injection of the Diodone.

3. Anoxia and congestion of the neck veins must be avoided by remote control of the airway.

![Figure 7](https://academic.oup.com/bja/article-abstract/24/4/252/318485)

Right carotid angiogram for the investigation of epilepsy in a man aged 51. Continuous needling (---N---) of the carotid artery for 24 minutes produced extreme hypotension necessitating the intravenous injection of methedrine 30 mg. (↓ M) in divided doses. A further drop in systolic and diastolic pressure occurred on injection of 32 ml. Diodone 40% (↓ 1.).
4. Non-explosive agents must be employed, for even though modern X-ray apparatus is spark proof, the proximity to potentially dangerous apparatus in my opinion necessitates the exclusion of all explosive anaesthetics.

Of the 102 cases under consideration 39 patients have been given 42 general anaesthetics for 62 angiograms. Figure 8 shows the age distribution and demonstrates that the majority of general anaesthetics have been given to the younger age groups. The main indications for a general anaesthetic

![Fig. 8](image)

Age distribution, the shaded cubes indicate the numbers in the different age groups that were given general anaesthetics for angiograms.
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...have been an unco-operative patient or a previous failure with local. Three “failures with local” refused to return for further investigations.

When using a general anaesthetic I premedicate adults with morphia gr. 1/6 (10 mg.), atropine gr. 1/100 (0.65 mg.), one and one quarter hours pre-operatively so that the maximum respiratory depression is passing off by the time the patient reaches the X-ray department. The morphia is omitted if the patient is drowsy or in poor general condition. Children may be given rectal thiopentone 1 g./50 lb. body weight and atropine gr. 1/100 (0.65 mg.) half an hour pre-operatively.

Whether local or general is used the patient must have an empty stomach prior to the injection of Diodone, for in a small percentage of cases vomiting is seen immediately following injection.

An endotracheal tube of adequate bore is essential for complete control of the airway, thus avoiding anoxia and venous congestion. Care must be taken that the tube does not become kinked at the level of the soft palate. The endotracheal tube is brought out of the side of the mouth and carefully placed so that it is not in the way of the radiologist or liable to appear on the exposed film.

For cardio-angiography at Guy's Hospital, Carnegie (1951) recommended endotracheal closed circuit cyclopropane and ether. This was to afford the patient protection from bronchospasm and transient anoxia associated with the introduction of 70 per cent Diodone on the venous side of the heart. In my experience of cerebral angiography, I have never observed bronchospasm associated with the injection of Diodone.

Anaesthesia is induced with minimal thiopentone, usually 500 mg., but often less will be required as these patients are not infrequently receiving long-acting barbiturates for
the control of fits. Gallamine triethiodide 60 to 80 mg. is injected through the same needle and the thiopentone syringe is replaced and strapped to the arm. A mask is applied and the patient is given pure oxygen by intermittent inflation of the lungs for 30 seconds by gentle pressure on the reservoir bag. When relaxation of the jaw occurs, a Macintosh laryngoscope is introduced, the larynx sprayed with 2 per cent amethocaine from a Rowbotham spray, the endotracheal tube passed and connected to a Boyle's machine. Anaesthesia is then maintained with 70 per cent nitrous oxide and 30 per cent oxygen with minimal trichlorethylene.

It is essential to intubate smoothly with no coughing and straining, otherwise the neck veins become distended and are liable to be damaged on seeking the carotid artery. The resultant haematoma may make it impossible to palpate the artery. If it is necessary to adjust the position of the patient relative to the X-ray film, a little more thiopentone may need to be injected. In the majority of cases spontaneous respiration is rapidly re-established but if the respiration is in any way depressed it is essential to assist it by compression of the reservoir bag. Recently I have used succinylcholine chloride, in intermittent injections of 50 mg., with nitrous oxide and oxygen during the period of apnoea. With this technique, however, I have found it difficult to maintain an even plane of anaesthesia and venous engorgement of the neck tended to occur. I have found succinylcholine of great value for peripheral angiography, e.g. for femoral angiograms, where the whole procedure is completed in three to five minutes. However, cerebral angiography takes considerably longer and large quantities may be required. In view of recent reports (Blair-Gould, 1952; Love, 1952; Harper, 1952) concerning prolonged apnoea following single doses of succinylcholine, I ques-
tion whether it is justifiable to use succinylcholine for maintenance. It may, however, have a place as a single dose for intubation. Using gallamine triethiodide I have found that a lighter plane of trichlorethylene anaesthesia suffices to give a smooth anaesthesia to ensure that the patient remains immobile during needling of the artery and injection of Diodone. I prefer gallamine triethiodide to d-tubocurarine chloride for the apnoea produced is usually transient. It is possible that the vagolytic action of gallamine triethiodide may be a factor in protecting the patient from stimulation of the carotid sinus. Tachycardia is seen in approximately 30 per cent of the cases; it does not, however, interfere with palpation of the artery as the blood-pressure is not reduced. Once the vessel is entered any movement, apart from blurring the films, may cause the point of the needle to come out of the artery and Diodone may be injected into the carotid sheath. The radiologist may not then be able to re-enter the artery. It is thus essential that the patient does not strain or move once the artery is entered. The trichlorethylene is cut off as the last injections are made, but the endotracheal tube is not removed until the films have been developed in case repeat injections are required. Anaesthesia is usually quite light and on extubation laryngeal spasm may occur (Gillespie, 1948). This is treated in the usual way by oxygen under pressure. Atropine gr. 1/50 (1.3 mg.) and neostigmine 5 mg. are rarely needed but are given if any residual respiratory depression is present.

COMPLICATIONS

These can be separated into those associated with puncture of the artery and those due to Diodone.

 Haematoma. A perivascular haematoma may develop from accidental damage to a vein or from puncture of the
artery. Cases have been reported where deviation of the trachea due to haematoma formation has resulted in respiratory obstruction (Dunsmore et al, 1951), and extra-vascular injection of Diodone may aggravate this. Aspiration of the haematoma may be required, but usually it disappears rapidly within twenty-four to thirty-six hours, not so much by absorption as by tracking down the carotid sheath into the mediastinum. Byrd and Jensen (1951) have described transient palsy of the vocal cords associated with deviation of the trachea with resultant respiratory obstruction. Foltz (1952) in experiments with monkeys showed that if Diodone is injected below the bifurcation of the carotid artery, swelling and œdema of the neck muscles and soft tissues can occur. This effect is due to the Diodone in the external carotid artery and is never seen following injection of the internal carotid alone. Following percutaneous injection in man, this swelling may be mistaken for local extravasation of blood or Diodone.

Cerebral Hæmorrhage. The ideal contrast medium for cerebral angiography has not yet been found. Foltz (1952) demonstrated a direct vascular effect on cerebral vessels after intra-arterial injection of Diodone. This consisted of a severe vascular spasm followed by prolonged vascular dilatation. Hæmorrhage into a tumour has been described following cerebral angiography (Bull, 1949). In our series a male patient aged 68 with three months’ history of amnesia and right hemiplegia of slow onset collapsed three hours after bilateral angiography under local anaesthesia. He died twelve hours later and, at post mortem, hæmorrhage into a left parietal tumour was found.

Hypotension and Cerebral Thrombosis. A generalized vascular dilation follows the entry of the Diodone into the general circulation. Figure 9 shows transient falls in both systolic and diastolic pressure related to the injection of
Bilateral carotid angiograms for the investigation of nominal aphasia of recent onset in a female aged 61. Needling (N) produced minor falls in blood-pressure whilst the injection of 32 ml. Diodone 40% at (1, 2, 3) resulted in more marked falls in both systolic and diastolic pressure.

Diodone: needling of the artery resulted in minor changes. At the end the blood pressure was at the preoperative level. This is in contrast to figure 10 which is drawn from pressures recorded during a bilateral angiogram in a hemiplegic man aged 50. Here progressive falls are seen with little subsequent recovery.

In elderly arteriosclerotic patients Ecker and Deren (1941) reported apoplexy apparently precipitated by hypotension. In our series one patient, a female aged 57, with a history of left hemiparesis nine years ago and a systolic bruit on the right side of the skull, collapsed whilst under going a right carotid angiogram under local anaesthesia. She developed a right hemiparesis and after initial improvement died within twenty four hours. At post
Bilateral carotid angiogram for the investigation of hemiparesis of slow onset, in a man aged 50. The procedure resulted in an overall fall in blood-pressure due to failure in recovery following the injection of 16 ml. 40% Diodone at ↓1, ↓2, ↓3, ↓4, ↓5.

Post-mortem, generalized cerebral atheroma was present. Just beyond the origin of the left middle cerebral artery there was a gross patch of atheroma practically occluding the artery, distal to which was an antemortem thrombosis which was the cause of death.

Vascular spasm may be the cause of hemiparesis and stellate ganglion block has been used by Dunsmore et al (1951) in America in an attempt to relieve vasospasm. It was not followed by immediate improvement though the patient recovered, apart from some residual slurring of speech. Chusid et al (1949) have described the use of tetra-ethyl ammonium chloride to relieve vessel spasm in two cases of transient hemiplegia with recovery in two to two and a half hours. It is possible that general anæs-
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Anaesthesia may mask transient paralysis or give protection against vasospastic reflex activity and thus inhibit hemiplegia.

**Prolonged Unconsciousness.** Prolonged unconsciousness can occur and was seen in two patients, both of whom were later diagnosed as having secondaries in the brain.

In one, a man aged thirty-one, investigated for hemiparesis of slow onset, a general anaesthetic had been given and he was still unconscious six hours after return to the ward. Atropine gr. 1/100 (0.65 mg.) followed by neostigmine 2.5 mg. had been administered before leaving the X-ray department. Respirations were not depressed. Blood-pressure was 130/100, pulse regular. 40 ml. of 50 per cent glucose was given intravenously as an internal hydrocephalus was shown on the angiograms. A return to consciousness followed and no aggravation of the existing paresis was evident next day.

**Ocular Complications.** Ocular complications from vasospasm have occurred and Falls et al (1951) describe temporary visual loss with subsequent full recovery in two patients but severe optic neuritis and permanent loss of vision in a third case. We have not encountered this complication in our series.

**Conclusions**

These anaesthetics are not difficult but a knowledge of the technique and the risks involved means that the anaesthetist can take steps to prevent unnecessary harm resulting from what is, after all, only a diagnostic procedure and not a cure, and enables him to play his part in the treatment of complications when they arise.

I should like to thank Dr. R. R. Hughes for his kind permission to report this series of cases.

**References**