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the ultimate triumph of good. He believed that social and political reforms were fully as important as scientific advances and fought for them with all his strength, uncompromisingly, antagonizing men of smaller stature, and yet all who knew him well knew his deep kindliness and human sympathy, respecting him as one who never deviated from a principle.

DISCUSSION

Dr. Bailey: I perceive Detroit is the proper place for the neurosurgeons to foregather. They seem to be rolling off the assembly lines like automobiles.

You perceive also how fortunate we are to have Dr. Sachs with us to deliver the Victor Horsley lecture. It is too bad that Dr. Sachs couldn't take more time to tell us more stories about Sir Victor Horsley. I suggest that some of you corner him at lunch and get him to tell you about the time Horsley sent him to take the spinal cord out of a whale.

Dr. Sachs: Excuse me, walrus.

Dr. Bailey: Walrus? I think you missed a good opportunity to follow Mark Twain who said, you know, that one should not spoil a good story by telling the exact truth. As far as I am concerned, it was a whale. [Laughter]

Well, we shall proceed now with the regular series of presentations on this subject which has been so adequately introduced to us. The first speaker will be Dr. Wycis, who, as you know, began, together with Dr. Spiegel, these applications which Clarke always looked forward to confidently.

[Dr. Wycis presented a paper on "Pallidotomy and pallido-amygdalotomy in certain types of convulsive disorders," by Drs. H. T. Wycis, H. W. Baird and E. A. Spiegel.]

Dr. Bailey: The next speaker will be Dr. Irving S. Cooper who will talk about chemopallidectomy.

CHEMOPALLIDECTOMY AND CHEMOTHALAMECTOMY*

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(Received for publication May 7, 1957)

IN THE development and evaluation of a neurosurgical technique the aim of which is to produce a lesion deep in the brain for the alleviation of hyperkinetic disorders there are six principal criteria by which a particular technique should be judged. These criteria are: (1) Accuracy of localization of the lesion. (2) Standardization of the technique so that with simple landmarks it is reproducible by many individual surgeons. (3) The ability of the technique to produce a lesion of sufficient size to alleviate the symptoms without necessarily inflicting undesirable sequelae. (4) Safety, so that the patient may undertake this particular type of therapy with a low risk of mortality or other complications. (5) Ability to inflict the destructive lesion

* Presented at the meeting of the Harvey Cushing Society, Detroit, Michigan, April 26, 1957. This investigation has been assisted by grants from the Sister Kenny Foundation and Josephine and A. P. Green Foundation.
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gradually and in a controlled fashion, thereby enabling the surgeon to vary the size and degree of neural destruction in individual cases. (6) The ability of the technique to produce good results consistently in a large series of cases.

Chemopallidectomy, as presently performed on our service at St. Barnabas Hospital, fulfills each of the criteria enumerated above. It is the purpose of this report to describe the present technique of chemopallidectomy and to note its results not only in cases of tremor and rigidity of parkinsonism, but also in cases of disorders of involuntary movement in children such as dystonia musculorum deformans, choreo-athetosis, and hemiballismus.

In brief, we presently perform chemopallidectomy* via a convexity approach by the following steps:

1. A pneumoencephalogram, using 30 cc. of air, is performed prior to operation. By means reported previously in detail,\(^2\,3\) a line (line C) is then drawn on the scalp which represents a plane 5 mm. behind the foramen of Monro. This line remains visible throughout the operation and serves as one of the two important external landmarks for orientation during the operation.

2. The patient is taken to the operating room and placed supine on the operating table. The procedure is performed under light Pentothal Sodium amnesia supplemented by local anesthesia at the site of operation.

3. A trephine opening is placed 5\(\frac{1}{2}\) cm. from the midline directly on line C, which represents the desired plane for insertion of cannula 5 mm. behind the foramen of Monro.

4. The chemopallidectomy guide\(^\dagger\) is placed on the scalp and fixed by fixation of the scalp so that the cannula holder is poised above the trephine opening on line C, thus insuring the fact that the cannula will be introduced into the brain in a plane 5 mm. behind the foramen of Monro.

5. We then use the second external landmark, which is the inner canthus of the ipsilateral eye. The cannula is placed in the guide and the tip of the cannula is directed towards the inner canthus of the eye. The cannula is then pushed 2 cm. into the brain substance. At this point the external landmarks have served their purpose and it is necessary to switch to the internal pneumoencephalographic landmarks before proceeding further.

6. A lateral and an anteroposterior roentgenogram of the skull are made in the operating room. They are developed on polaroid film so that the pictures become available in 50 seconds. These films are checked to see whether the cannula, if it is pushed to its proper depth in the brain, will come to lie at the desired points, that is point X in the anteroposterior film and point 0 in the lateral film. These anatomic landmarks have been described in detail in earlier communications and will not be repeated here.\(^2\,3\).

7. When it is observed that the cannula is aimed at the proper points, it may then be placed at its proper depth, which is at the level of the middle of the third ventricle. This is usually 6.5 cm. beneath the cortex. If it is not aimed at the proper point a correction in its position is made and it is rechecked roentgenographically until it has assumed the proper position.

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* The technique described herein includes certain modifications made since this paper was presented in April 1957.

\(^\dagger\) Manufactured by Invengineering Inc., Belmar, New Jersey.
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Fig. 1. Chemopallidectomy cannula currently in use. This cannula has a solid stainless steel stylet for insertion of the cannula and a polyethylene stylet which is used to allow the cannula to remain indwelling in the brain. It is also equipped with a double lumen, one for inflation of a small balloon at the end of the cannula, the other for injection of a neurolytic agent into the brain.

8. A balloon at the end of the double-lumen cannula is inflated by injection of Hypaque into the lumen leading to this balloon1 (Figs. 1 and 2). This provides two functions: 1) It forms a cavity for later injection of Etopalin into the brain, thereby preventing any spread or reflux of the neurolytic agent. 2) It provides a physiologic lesion in the globus which temporarily alleviates contralateral tremor and rigidity when the cannula has been properly localized.

9. The cannula is fixed in place and the patient is returned to his room, allowing the cannula to remain indwelling in the brain for later gradual infliction of the lesion.

10. The patient is allowed to be ambulatory on the following morning. The

Fig. 2. (Left) Inflation of balloon after its placement into the globus pallidus. In this case $\frac{1}{2}$ cc. of Hypaque was injected into the balloon.

Fig. 3. (Right) Lateral roentgenogram demonstrating inflation of balloon in the mesial globus. Note its position immediately behind the foramen of Monro.
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Fig. 4. (Left) Anteroposterior roentgenogram demonstrating large lesion produced by injection of Etopalin plus Pantopaque through the indwelling catheter. This lesion produced complete alleviation of contralateral tremor and rigidity. In this case a simple chemopallidectomy cannula without the balloon was used.

Fig. 5. (Right) Roentgenogram demonstrating radio-opaque lesion produced by injection of Etopalin-Pantopaque into the cavity made by prior inflation of the balloon in the globus pallidus. This lesion was made by three injections of 0.5 cc. Etopalin-Pantopaque following deflation of the balloon. The lesion produced complete alleviation of contralateral tremor and rigidity.

Fig. 6. In some instances a second lesion is placed behind the first in order to completely alleviate tremor. This diagrammatic drawing illustrates the two principal lesions that we use. The anterior lesion is the pallidal lesion. The posterior lesion is the thalamic lesion.

A series of alcohol or Etopalin* injections is begun 24 to 48 hours after surgery. At this time the intracerebral balloon is deflated and the first injection of alcohol is carried out.

* Supplied by Ciba Pharmaceutical Co., Summit, New Jersey.
11. All injections are carried out with the patient in a sitting position after the position of the cannula has been checked roentgenographically. We now start with a small injection of approximately $5/10$ cc. of alcohol and then perform injection of $5/10$ to $7/10$ cc. on 2 or 3 occasions over a period averaging 7 days. Our neurolytic agent, alcohol, is mixed with iophendylate so that the production of the lesion may be followed roentgenographically. The end point is reached when we have achieved the desired clinical result and when the roentgenographic appearance of the lesion seems to us adequate, as judged by previous experience (Figs. 3, 4, 5 and 6).

12. If, 1 week after surgery, we are not satisfied that the symptoms are being adequately relieved, the patient is returned to the operating room and a second cannula is placed by hand, usually approximately 7–13 mm. behind the first. A second lesion is then placed in the brain at this location and almost invariably the summation effect of these two lesions will produce the desired result.

13. As a result of experience with the posterior lesion mentioned above, we have learned that this posterior location is the most efficacious region in which to place a lesion for the relief of parkinsonian tremor and other involuntary movements. A series of 65 operations on cadavers identified this locus as the region of the ventrolateral nucleus of the thalamus.

It has become our practice during the past 200 cases to place the initial lesion in this thalamic location. This lesion is located slightly behind the midway point between the posterior margin of the foramen of Monro and the pineal gland. Roentgenographic landmarks for the thalamic lesion as compared with the pallidal lesion are shown in Fig. 7.

The use of this thalamic lesion is to be preferred to the pallidal lesion for relief of parkinsonian tremor. Moreover, it is also effective in relieving rigidity.

RESULTS

Up to the present time* more than 650 chemopallidectomies have been performed for tremor and rigidity of parkinsonism. Rigidity has been relieved in 80 cent of these cases and tremor has been relieved in slightly over

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* Since presentation of this paper in April 1957, the results have been brought up to date of February 1958 in order to provide more recent information.
75 per cent. These figures refer to cases in which the operation was done from 3 months to 4 years ago and in which there has been no recurrence of symptoms up to the time of this report. Because of gradual technical improvements in the operative procedure and more knowledgeable selection of patients for surgery, chemopallidectomy has become increasingly successful and carries a minimal risk. In the past 100 cases, rigidity has been relieved in 90 per cent whereas tremor was relieved in 85 per cent of these cases. Detailed reports of many of these cases appear elsewhere. Moreover, motion picture records before and after surgery, as well as the research archives of each case are available for objective study.

The mortality rate for the entire series of chemopallidectomy is 2.4 per cent. However, we have recently completed 150 consecutive cases of chemopallidectomy without a single fatality. The incidence of hemiparesis is 2 per cent.

Forty chemopallidectomies for other disorders of involuntary movement in children and adults have been carried out. In these cases the most effective lesion is the posterior or thalamic lesion described above. It must be emphasized that the exact anatomic structures affected in individual cases is not yet certain because of lack of autopsy material. However, our anatomic studies plus a large series of operations on cadavers lead us to conclude that interruption of fibre connections between the globus pallidus and the ventrolateral nucleus of the thalamus are particularly important in this regard. Moreover, a lesion placed directly within the thalamus is even more effective than one placed in the pallidothalamic pathways. There is some evidence that interruption of cerebellothalamocortical connections contribute to the clinical results that we obtain with the thalamic lesion. In more than two-thirds of these cases this procedure has alleviated the hyperkinetic manifestations and deformities of dystonia musculorum deformans, choreo-athetosis and hemiballismus. Both choreo-athetosis and dystonia have been relieved for more than 2 years by this procedure without recurrence up to the present time.

SUMMARY

Chemopallidectomy and/or chemothalamectomy in properly selected cases, if performed accurately and with meticulous attention to the postoperative regimen of intracerebral injection, will provide lasting alleviation of tremor and rigidity in more than 80 per cent of the cases of parkinsonism. The mortality rate is 2.4 per cent. The incidence of lasting hemiplegia is 2 per cent. In certain cases the involuntary movements and deformities of dystonia, choreo-athetosis and hemiballismus have also been completely reversed by this procedure, without sacrifice of motor function.

Chemopallidectomy and thalamectomy as presently employed on our service are, in our opinion, now capable of employment as a routine neurosurgical procedure in diverse but meticulously selected cases of extrapyramidal disorders. The procedure has the following advantages:
1. It has been developed and tested in a consecutive series of more than 650 cases. Good results have been obtained consistently with a low incidence of complication.

2. It is simple, safe, accurate, and consistent once one is conversant with its details.

3. The indwelling intracerebral catheter makes chemopallidectomy capable of producing an adequately sized lesion deep in the cerebrum in gradual increments over a period of 2 to 7 days, or longer if necessary. This facility of gradual infliction of a deep lesion in a conscious, cooperative patient allows the surgeon to maintain better control over the postoperative situation by working up to a lesion large enough to alleviate the disabling symptoms without inflicting undesirable side effects. Moreover, with the indwelling cannula-balloon-Etopalin-iophendylate technique of producing the lesion, the size and boundaries of the lesion can be constantly controlled and visualized roentgenographically. Thus, the surgeon can simultaneously judge the intracerebral lesion and the clinical result being effected by chemopallidectomy or thalamectomy.

REFERENCES


DISCUSSION

Dr. Bailey: The next speaker will be Dr. Kjellberg.

[Dr. Kjellberg read a paper entitled “Stereotactic surgery for involuntary movements,” by Drs. W. H. Sweet and R. N. Kjellberg.]

Dr. Bailey: These reports by Dr. Cooper and Dr. Kjellberg are certainly very encouraging.

We shall now hear from Dr. C. M. Bertrand.