

On the other hand, of the 25 patients who were still alive, the average survival has been 13 years, and 12 consider themselves to be completely well with full earning capacity. Only four are complete invalids. Amongst this group were five patients with cystic tumours, where only the cysts were evacuated and the interior fixed with Zenker's fluid. They have lived from five to 20 years, whilst four patients with solid tumours have been followed up for an average of 19½ years. The conclusion that some acoustic tumours grow imperceptibly or cease to grow after incomplete removal is inescapable.

Complete Extirpation.—Of the 166 patients, 10 have not been heard from. Nine patients were dead from intercurrent disease. There remained 139 cases, 63, or nearly 50%, were well, with full

working capacity; 54 had good but somewhat reduced capacity; 22 were invalids. The causes of invalidism were: Blindness 7, and cerebellar incoordination 15.

Of the 62 survivors in the group where the facial nerve was preserved, the face recovered in about two-thirds of the cases. Working capacity in this group has been the best of all; only four patients were complete invalids (two blind). The length of time required for rehabilitation was much shorter in this group.

To sum up, 29% of patients with incomplete removals died at once; 24% were dead in three to four years, and only 25% are reasonably well at the end of 13 years, whereas, of the total removals, 23.5% died at once, and 55% were well and working after seven years.

RESULTS IN 130 CASES OF ACOUSTIC NEURINOMA

BY

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We have recently made a survey of the 130 cases of acoustic neurinoma which have passed through our hands during the past 20 years at the London Hospital and in the Nuffield Department of Surgery in Oxford. Our interest has been chiefly in the functional results of the different operative procedures commonly practised, as we consider that the clinical picture of a cerebello-pontine angle tumour is sufficiently familiar to most neurological surgeons to indicate the site of an exploration. The variations in operative procedure according to the type of tumour (acoustic tumour, meningioma, cholesteatoma, etc.) can be decided when the tumour is exposed at operation.

Migration of the population during the war, difficulties in travelling, and the general preoccupation with more urgent matters interrupted our routine follow-up investigations in many cases, and our present information is by no means complete. In 17 cases we have as yet no useful follow-up studies and in another 15 the information is not up-to-date. This is accordingly an interim report, but it is unlikely that subsequent information will alter our conclusions significantly.

Our cases fall into four groups depending on the method of treatment undertaken (Table I). First there was a group of 10 patients who had no operative treatment. The second group of 12 patients had only a decompression, usually suboccipital. The third group was the most numerous, com-

prising 102 patients in whom an incomplete removal of the tumour was done. In the fourth group of 25 patients the tumour was completely removed. It will be seen that the total is greater than our total number of cases owing to the fact that some of the patients treated by decompression subsequently had incomplete or complete removal of their tumour, while some of those treated by incomplete removal subsequently had the tumour completely removed.

Group I : No Operative Treatment

This group (10 cases) is largely unverified as some of the patients are still alive and others died in circumstances not permitting a necropsy, but the clinical features left little doubt about the diagnosis.

Inoperable.—Six patients were considered to be "inoperable", or too ill to stand operation. When first seen most of them were blind and had gross ataxy, as well as dysarthria, dysphagia, and the like. In this connexion we believe that if a patient is already irreparably blind from an acoustic tumour the prospects are unfavourable. After operation for an acoustic tumour it is usually necessary to learn to walk again, and the combination of blindness with ataxia makes this such a difficult task that in practice it is rarely done. We have found that the patient who is both totally blind and ataxic is usually consigned to an inactive existence because no one has time to look after him. However, it is sometimes necessary to operate on unfavourable or

TABLE I
ANALYSIS OF 130 CASES OF ACOUSTIC NEURINOMA*

	Post-operative Deaths		Interval Death	Living		Follow-up Incomplete	Total
	After First Operation	After Later Operation		Working	Invalid		
I. No operative treatment ..	—	—	—	—	—	—	10
II. Decompression alone ..	1	—	—	—	7	2	10
III. Incomplete removal—							
Cystic tumour	—	4	—	6	—	—	10
Incomplete removal of meatal part	1	—	—	6	—	—	7
Intracapsular	9	7	7	40	11	11	85
IV. Complete removal.. ..	4	—	—	12	5	4	25

* A number of the cases appear in more than one group.

desperate cases if for no other reason than to provide relief of headache.

Most of the inoperable cases occurred in the early years of the series, and we are impressed by the fact that diagnosis generally has improved so much that patients are referred for treatment much earlier than in the past.

While in general we welcome early diagnosis it is sometimes possible to make the diagnosis long before there is any indication for operation. In such cases we think it unwise to acquaint the patient with the diagnosis until it is time to operate on him. Faced with the knowledge of a "tumour on his brain" even a stolid patient may find the burden of worry intolerable until the lesion has been dealt with, and the surgeon's hand is forced. In our experience operation in such cases is often very difficult: the tumour may be small, situated far forward and medially, and the technical difficulty of removing it may be such that the patient finds that he has much more of a disability after the operation than he had before. These remarks do not apply to the rare cases of very small tumours in the eighth nerve which can be detected and removed in the earliest stage without any damage to the facial nerve.

Palliative Treatment Only.—One patient was 74 years old when she presented herself with paroxysmal trigeminal neuralgia on the same side as other signs indicating an acoustic tumour. She was only concerned about the pain and this was relieved by an alcohol injection of the infraorbital nerve.

Under Observation.—One patient was a boy who had the clinical features of multiple neurofibromata on the cranial nerves including both eighth nerves, but he had no symptoms or signs of increased intracranial pressure and was still at school. Two other patients, both elderly, with slight symptoms and signs of an acoustic tumour have been observed for 10 and two years respectively and have had no treatment. As they are in no way disabled and can lead active and useful lives it would obviously be meddlesome to interfere with them.

Speaking generally, we recognize two indications for operation; (1) symptoms and signs of increased intracranial pressure, and (2) impending physical disability from ataxy, disturbance of speech, swallowing, etc. As mentioned above there are many cases in which the diagnosis can be made before either of these indications occurs; in such cases we prefer to keep the patient under regular observation.

Group II : Decompression

This group comprised 12 cases, with the following results.

- 1 operative death.
- 5 patients required subsequent operations after 1 month, 2 months, 4 months, 9 months, 5 years.
- 4 patients had relief for 4 years, 6 years, 10 years, 12 years.
- 2 with insufficient follow-up information.

We consider that there are two indications for this procedure: (1) To provide immediate relief of increased intracranial pressure in a patient who is

considered to be too ill to tolerate a more radical operation; (2) to provide relief of pressure in cases in which symptoms and signs of increased intracranial pressure predominate over focal neurological abnormalities, i.e. in those patients who have intense headache, papilloedema and failing vision with little or no ataxy, dysarthria, dysphagia, and the like. In this series of 12 cases there were five in which decompression gave the required relief from symptoms for four to 12 years. One of these subsequently developed further symptoms and had to have his tumour removed. In four other cases the decompression did not accomplish its object, and a further operation was required one to nine months after the decompression. All of these patients were over the age of 50 when they came for treatment.

In our view, decompression has its uses in selected cases, especially in elderly subjects. If a subsequent operation becomes necessary we have not found that the decompression renders it any more dangerous. The type of decompression which we have commonly used is identical with the exposure for removal of an acoustic tumour, so that at the second operation the tumour is easily approached by re-opening the old wound.

Group III: Incomplete Removal

An incomplete removal was done in 102 cases. We have subdivided this group into three: (1) Cystic tumours; (2) tumours in which the removal was complete except that the meatal extension was not removed; (3) intra-capsular removal, the classical operation of Cushing.

(1) **Cystic Tumours (10 Cases).**—This type of tumour responds well to the incomplete operation. Of our 10 patients six have remained well, leading active and useful lives for three to 12 years since operation. Four others required subsequent operations six months to four years after the first operation, and all of these died. Two of the deaths were from meningitis; and in one, which was a case of very extensive and frequently recurring tumour, death followed soon after the fourth operation from an unrecognized extradural haemorrhage of the middle fossa.

These cystic tumours are not to be confused with the subarachnoid collection of yellow fluid which usually covers the posterior surface of the solid tumours. In the cystic tumours the greater part of the tumour is cystic, and release of the fluid relieves the pressure and re-establishes the circulation of the C.S.F. The solid mass is usually on the medial wall of the tumour, and usually all that is necessary is to pull this gently away from the side of the pons.

The result is usually a full functional recovery with preservation of the facial nerve. In our series the results of re-operation were particularly unfavourable, but this is a coincidence since the causes of death were from risks inherent in operation for any type of adult hydrocephalus, and were not a particular hazard of secondary operations for acoustic tumour.

(2) Incomplete Removal of Meatal Part (7 Cases).

—There were seven cases in which the tumour was completely removed except for the meatal part of the tumour which was left behind in an attempt to conserve the facial nerve. One patient died of haemorrhage into the tumour bed. All the other patients did well and returned to their normal life and occupation, but in one case after six years the tumour recurred, and at operation was almost as large as the original tumour. We have usually found it impossible to remove the meatal part of the tumour without destroying the facial nerve.

TABLE II

RESULTS OF INTRACAPSULAR REMOVAL OF TUMOUR IN 85 CASES

Died after first operation	9
Died later	14
At work	For 5 to 10 years	14
	" 3 to 5 "	12
	" 2 to 3 "	6
	" less than 2 years	8
		—
		40
Living but not working	11
Untraced	11
		—
		85
		—
<hr/>		
<i>Subsequent operation</i>		
	1 year or less after first operation	3
	1-2 years " " " "	3
	2-3 " " " "	7
	3-4 " " " "	1
		—
		14
		—
Operative deaths 7 (2 from infection)		
<hr/>		
<i>Causes of death</i>		
	Operation	16 (19%)
	Due to symptoms of tumour	4
	"Pneumonia" 3 years after operation	1
	"Angina" 2 " " "	1
	Suicide 18 months, " "	1
		—
		23
		—

(3) **Intracapsular Removal (85 Cases).**—Nine of these patients (Table II) died as a result of the first operation (10%). Fourteen of the 76 survivors required further operations within four years and of these no less than seven died, a mortality rate of

50%. In all, 23 of these patients are known to be dead. Of the remainder 40 are known to be at "full work" or "leading a normal life" for periods up to 10 years after operation. In 11 patients alive but not working there are varying degrees of disability from slight unsteadiness of gait to the complete invalidism which so often results from blindness and ataxy in these cases. The remaining 11 cases have not been traced.

The results of this type of operation depend largely on how extensive it is. It entails, of course, a cerebellar decompression with the possible benefits which may derive from that alone; generally the excision of a portion of the lateral lobe of the cerebellum to expose the tumour, and this provides some more room; and excision of a part of the tumour, which is obviously the essential part of the operation. It is not sufficient to "peck" at the tumour; unless enough is removed to allow the capsule to be pulled out of the tentorial notch (in which it is usually impacted), obstruction to the circulation of the cerebrospinal fluid will continue, with loculation of cerebrospinal fluid in the posterior fossa and a tense bulging decompression. In these circumstances the operation will have accomplished little more than a simple cerebellar decompression. Indeed, the result may be less satisfactory than a simple decompression, because so much of the arachnoid membrane is destroyed. Unless the capsule is freed and withdrawn from the pons and the lower cranial nerves there is likely to be little improvement in the neurological signs.

Disimpaction from the tentorial notch usually means seeing the fifth nerve and the arachnoid of the cisterna ambiens, and there is usually a gush of cerebrospinal fluid from above the tumour. It is more difficult to say whether the tumour has been adequately freed from the brain stem, and as this is probably the most dangerous part of the operation, there is a tendency to leave too much behind; indeed, in cases which have died after operation we have usually been surprised at the amount of tumour remaining.

TABLE III

COMPLETE REMOVAL OF THE TUMOUR (25 CASES)

- 4 operative deaths (2 "pontine oedema," 1 *Bact. coli* infection, 1 extradural haematoma).
- 4 had had 2 or more previous operations. (One of these died from extradural haematoma.)

Functional Results

- 2 had gross residual disabilities.
- 3 had minor disabilities but were able to lead a restricted life.
- 12 known to have resumed a "normal life" for periods ranging from 1 to 15 years.
- 3 had no facial paralysis.
- 4 unknown.

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Group IV : Complete Removal

There were 25 cases in which the tumour was completely removed (Table III). There were four operative deaths, two of which have been mentioned in the preceding section and these patients had had previous incomplete removals. The other two deaths were ascribed to "pontine oedema", a vague description of a clinical state familiar to most surgeons who have had experience of these tumours. At the end of the operation the tumour cavity looks dry, and the general physiological state is satisfactory. Within a few hours, however, there is tachycardia, fall of blood pressure, slow and laboured breathing, increasing dysarthria and dysphagia, then coma leading rapidly to death. At necropsy there is usually no obvious cause for death, no clot, obvious contusion or herniation. It is probable that this state results from interruption of blood vessels on the side of the brain stem when the tumour is being dissected from that structure. And indeed when we see acoustic tumours at necropsy and realize how deeply embedded in the brain stem they may be, and how intimate may be their relationship to the basilar artery and its branches, we can appreciate Dr. Cushing's doubt as to "whether one of these lesions can with safety be totally enucleated".

As to the functional results, 12 of these patients are known to have resumed a normal life, which is to say that they had minimal neurological deficits apart from a facial palsy which occurred in all except three cases. Recovery from ataxy, dysarthria, dysphagia, etc., is often quite rapid after operation, but may go on for two to three years afterwards. Thereafter improvement is usually a matter of continued re-education and adaptation to what deficit remains.

Three patients were left with mild disabilities, and two were grossly disabled, chiefly because of ataxy, which if coupled with defective eyesight and advancing age is indeed a formidable handicap. There is no doubt that morale plays a large part in the degree of recovery: one patient may have a profound ataxy and be little inconvenienced by it, and another with very slight ataxy may remain almost an invalid. Next in importance to this personal factor is encouragement and assistance in re-educative activities by friends and relatives. The rehabilitation of a patient with a cerebellar disability may be a very time-consuming process, which makes demands not only on the patient but on those associated with him.

As mentioned above all except three of these patients were left with a complete facial paralysis on the side of the lesion, and this is not surprising in view of the fact that complete removal often entails

curettage of the meatus. In cases of complete removal in which the nerve is thought to be intact, or those in which a fragment of tumour has been left at the meatus in a deliberate effort to save the nerve, there may be a complete facial paralysis for some weeks or months after which recovery may begin. We mention this fact because it may save some needless anastomosing operations. We have done very few anastomoses in these cases because we think that the grimacing which occurs afterwards is almost as unsightly as the facial palsy. By various plastic procedures reasonable symmetry at rest can be preserved, and the deforming, wasting and contractures can be prevented by regular and persistent galvanic treatment. In cases in which the patient wants help in making a decision as to his facial palsy we arrange for him to see a patient who has had a successful anastomosis and one who has been treated otherwise, so that he can make his own choice.

The combination of facial paralysis and trigeminal anaesthesia required tarsorrhaphy in several cases to prevent corneal ulceration. In two cases in which this was not done keratitis began shortly after the patient left hospital and irreparable scarring occurred before a tarsorrhaphy was done. When vision is already impaired due to secondary optic atrophy, this may be a grave loss, and we now feel that tarsorrhaphy should be done immediately in all cases in which after operation there is anaesthesia of the cornea, and inability to close the eye. The tarsorrhaphy can be released when, as often happens, corneal sensation returns.

In two cases of trigeminal anaesthesia there was trophic ulceration of the nostril. In one case there was such severe loss of tissue that an elaborate reconstruction operation had to be done.

Discussion

In summary we feel that each of the procedures mentioned above has its uses in certain cases, and that there is no one method which is universally applicable, correct, and wise. Although the operation for acoustic tumour is a "set piece" of neurological surgery, the problem for the surgeon is not simply the technical one of removing the tumour. He must know from his own examination how much of a neurological deficit there is, and how this affects the patient in his work and his daily life. He should have seen the patient getting about the ward, having his meals, and attending to himself. He should be familiar with the domestic and economic background, and know how much assistance can be mustered for convalescence and rehabilitation. And he should know something of the patient's moral and intellec-

tual reserve in the event that he is left with a disability.

The operation of complete removal is the most satisfying technical achievement for the surgeon, satisfying because it is an achievement and because he knows that this particular tumour will cause no more trouble. But if in so doing he has created a cerebellar invalid—as may happen despite all reasonable care during the operation—there is little to be said for this pursuit of a surgical ideal when something less radical might have produced a better result. It is noteworthy that in this series the mortality rate for complete removals (16%) was lower than that for incomplete removals (19%), but there were many fewer of the former, and there is no doubt that we have often been led on to a complete removal by the fact that "things were going well" during the operation, whereas in many of the incomplete removals there were such difficulties that had we persisted in an obstinate attempt at a complete removal the patient would have succumbed or have been left an invalid. In general we feel that the policy of complete removal has most to be said for it in young subjects with their whole life before them: it is an end to the trouble which the tumour may cause, and their youth will aid them to compensate for any residual deficit. In older subjects with family commitments and the like, all of the factors mentioned in the preceding paragraph need to be considered, and in many of these we believe that an incomplete removal may be preferable.

But there is also the question of facial paralysis which must be faced in each individual case. Before operation the degree of facial palsy is so slight in most patients as not to be disfiguring. The risk of producing complete paralysis is considerable during intracapsular removal and extremely high in complete removal. Complete facial paralysis seems a small price to pay for relief from an acoustic tumour, but there are some women who seem unable to appreciate this. Some years ago one of us reported a small series of cases in which it was possible to conserve the facial nerve during complete removal of the tumour (Cairns, 1931); but with further experience it has become clear that the number of cases in which the facial nerve can be effectively conserved during complete removal of the tumour, including the extension into the internal auditory meatus, is small. With few exceptions it is limited to the cases in which there is no extension of tumour into the meatus. There are certain patients, mostly young women with mobile features, in whom it is essential to do everything possible to conserve the function of the facial nerve; and this usually requires an incomplete operation, with the

minimum interference in the region of the internal auditory meatus. The facial nerve is usually found on the front of the tumour capsule when the excavated lower pole of the tumour is lifted upwards, though in occasional cases it lies behind the tumour. Nothing short of a very thorough intracapsular removal of the tumour is likely to relieve the symptoms of raised intracranial pressure in most cases, and hence it is not surprising that many of our attempts to conserve facial nerve function have ended in failure.

As more neurosurgical centres are opened in this country it is unlikely that any one surgeon will deal with a sufficient number of acoustic tumours to become practised in the way possible with other set procedures such as those for trigeminal neuralgia, pituitary tumours, and other types of brain tumour. Each case should thus be regarded as an opportunity for perfecting our technique, and to the young surgeon we would say that an operation for acoustic tumour is a good day's work : it is generally a mistake to operate against the clock.

In treating brain tumours it is usually possible for the young neurosurgeon to proceed cautiously without endangering his patient : for example, the large and vascular meningioma of the cerebral hemisphere can be dealt with in two or more stages. In acoustic tumours, on the other hand, the two-stage operation is of little or no use. It is essential at the first operation, in most cases, to remove sufficient tumour to re-establish the flow of cerebrospinal fluid through the tentorial opening, and to free the pons and medulla from pressure ; and that requires at the least a very thorough intracapsular removal of

the tumour, and pulling away of the tumour capsule from the tentorial opening and the side of the pons. Nothing less, in most cases, will render the patient capable of returning to active life. On the other hand, radical and complete removal of acoustic tumours has in the past carried a high operative mortality, even in the hands of the most expert and experienced neurosurgeons ; and it is easy for the young surgeon of radical intent to lose two or three successive cases of acoustic tumour, with the result that he tends to treat the next case with an inadequate intracapsular operation. There is danger in doing so much as to damage fatally the adjacent vital centres ; there is danger in doing too little to relieve the patient's symptoms.

The outlook, however, is far from gloomy. In 1917 Dr. Cushing qualified his doubt about the feasibility of complete removal of acoustic tumour by saying " unless some more perfected method is devised ". The introduction of electrosurgery 10 years later was a great technical advance, and more recently the adoption of the sitting position has provided another improvement. In addition, the prophylactic use of penicillin has almost eliminated the risk of meningitis, which formerly was high in these operations, for some reason not wholly explained. There is thus every prospect that with bold design and gentle manipulative technique, the next decade will show considerable improvement in the treatment of acoustic tumours.

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ACOUSTIC NEURINOMA

BY

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My personal experience of operation for acoustic neurofibroma comprises 47 patients, on whom 57 operations were performed, with 18 deaths.* The following is a brief analysis of these operations :—

- Total enucleation
(in one stage) : 25 patients 6 deaths ; mortality 24%
- Total enucleation
(multiple stages) : 8 patients 5 deaths ; mortality 63%
(total mortality for enucleation : 33%)
- Partial removal : 14 patients 3 died ; mortality 20%
(further operation necessary : 5 patients 3 died,
and one died subsequently of the tumour
(ultimate mortality for partial removal 50%)

* This report includes cases up to October, 1949.

- Suboccipital decompression alone : 2 patients 2 died
- Emergency ventricular tap : 1 patient 1 died
- Totals : case mortality 38%. Operation mortality 32%.

The operation of choice in the earlier years was a partial (intracapsular) removal, but largely as a result of the experience of Horrax, I decided to attempt primary total extirpation more frequently, and this has been my endeavour since about 1942.

This series of cases is too small for reliance to be placed upon percentages, although the mortality figures for one-stage partial and one-stage complete removals are not dissimilar. The figures are to some extent misleading, in that there has been evident selection of cases for radical operation