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Posterior fossa tumours in childhood: associated speech and language disorders post-surgery

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Abstract

Six children aged between 6 and 16 years who had undergone surgery for the removal of a posterior fossa tumour were assessed at least one year post-operatively to determine the incidence and severity of any associated speech or language deficits. Five males and one female were included in the sample. The subjects were administered a battery of speech/language assessments including: a language screening test, an articulation test, a dysarthria assessment and a perceptual speech analysis. The results indicated that dysarthria and/or language impairment occurs in some cases subsequent to surgical removal of posterior fossa tumours. The occurrence of muteness immediately post-surgery would appear to indicate a poor prognosis for speech abilities. A possible link between the occurrence of long term language disabilities in these children and post-surgical radiotherapy is documented.

Introduction

Brain tumours are a recognized cause of acquired speech and language disorders in children (Alajouanine and Lhermitte 1965, Hecaen 1976, Carrow-Woolfolk and Lynch 1982, Rekate, Grubb, Aram, Hahn and Ratcheson 1985, Van Dongen, Loonen and Van Dongen 1985, Volcan, Cole and Johnston 1986). Although posterior fossa tumours account for over half of all paediatric intracranial neoplasms (Matson 1956, Farwell, Dohrmann and Flannery 1977, Naidich and Zimmerman 1984, Segall, Batnitzky, Zee, Ahmadi, Bird and Cohen 1985) little information is available in the literature on the speech/language abilities of children who have had such tumours surgically removed.

A transient mutism, which eventually resolved into an ataxic dysarthria, was reported in two recent studies to occur in children subsequent to the surgical removal of posterior fossa tumours (Rekate *et al.* 1985, Volcan *et al.* 1986). Rekate *et al.* (1985) reviewed six children aged between 2 and 11 years who had experienced acute bilateral damage, due to the presence of tumours, to large areas of both cerebellar hemispheres. Their sample included four children with medulloblastoma, one with astrocytoma and one with ependymoma. All of these children were described as being mute for one to three months post-surgery, the muteness in most cases resolving to a mild residual cerebellar (ataxic) dysarthria. One subject was described by Rekate *et al.* (1985) as

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having normal speech six months post-surgery. Another case of muteness preceding dysarthria subsequent to removal of a posterior fossa tumour was reported by Volcan *et al.* (1986). They described an eight-year-old girl who had a medulloblastoma removed from the fourth ventricle which resulted in a mild right paresis, truncal ataxia, signs of right cerebellar dysfunction and muteness. Within two weeks post-surgery, she had regained monosyllabic speech but was described as having a monotonous tone and dysarthria.

Other authors have also reported the occurrence of ataxic dysarthria in association with posterior fossa tumours (Gold 1980, Brown 1985). However, in all studies reported to date, ataxic dysarthria is used as a global term and detailed descriptions of the speech abilities of each subject are not included. Consequently, the detailed characteristics of any speech disorder exhibited by children following surgical removal of posterior fossa tumours remains unknown and further research to delineate the specific features of these disorders, particularly in the long term, is warranted.

Although some authors have indicated that brain tumours may be a cause of acquired aphasia in childhood (Carrow-Woolfolk and Lynch 1982), there are no reports in the literature which document the findings of a comprehensive investigation of the language abilities of children following removal of a posterior fossa tumour. Even though the site of these tumours would not in itself lead to the prediction of an associated language deficit, there are a number of factors occurring secondary to the presence and removal of posterior fossa tumours that could conceivably disturb language function. Hydrocephalus usually accompanies posterior fossa tumours because, in many cases, these tumours either emerge from or invade the fourth ventricle thereby obstructing the flow of cerebrospinal fluid (Lothman and Ferrendelli 1980). Subsequent dilation of the ventricular system may result in compression of the cerebral cortex. In addition, radiotherapy, often administered after surgical removal of posterior fossa tumours in order to prevent tumour spread or recurrence, has been reported to cause aphasia in some adults and intellectual deficits in some children (Broadbent, Barnes and Wheeler 1981, Meadows, Massari, Fergusson, Gordon, Littman and Moss 1981, Danoff, Cowchock, Marquette, Mulgrew and Kramer 1982, Duffner, Cohen and Thomas 1983, Kun, Mulhern and Crisco 1983, Burns and Boyle 1984, Silverman, Palkes, Talent, Kovnar, Clouse and Thomas 1984). Further, the negative effects of radiotherapy have been reported to appear as delayed reactions, so that any associated language deficit may only appear in the long term (Hodges and Smith 1983, Pearson, Campbell, McAllister and Pearson 1983).

The aim of the present study was to determine the presence or absence of long term speech and language deficits in a group of children who had undergone surgery to remove a posterior fossa tumour. In addition, the specific characteristics of any identified communication disorder were to be described and factors contributing to their nature and severity delineated.

Methods

Subjects

Six subjects (5 male, 1 female) aged between 6 years 6 months and 16 years 9 months (mean = 11 years 3 months, standard deviation = 3 years 10 months) were assessed

using a battery of standardized speech and language assessments. All subjects underwent posterior fossa tumour removal at least 12 months prior to assessment. The subjects had no history of birth trauma, head trauma, intellectual handicap, premorbid speech and/or language deficit or other neurological disorders. All subjects were monolingual speakers of Australian English. The six subjects included represented all surviving posterior fossa tumour cases who met the above inclusion criteria and who presented at the Mater Misericordiae Hospital, Brisbane between August 1980 and April 1985. Two other subjects who met the inclusion criteria were either unwilling or unable due to geographical location to participate in the study. Reports of pre-operative hearing abnormalities were not present in any of the subjects' medical charts.

Procedures

Prior to administration of the speech/language test battery, a parent of each child completed a questionnaire requesting information on each child's communication, academic and personality characteristics before and after tumour removal. All testing was carried out in quiet surroundings in each subject's home, the tests being administered in strict accordance with the instructions detailed in their respective manuals.

Test battery

A series of tests were administered to assess the speech abilities of each subject. These tests included:

(1) *The Fisher-Logemann Test of Articulation Competence* (Fisher and Logemann 1975). This test systematically examines articulatory accuracy in single word productions. The consistency of speech sound productions can also be considered. Each subject's speech was analysed both phonetically (analysis of sound errors) and phonologically (analysis of phonological processes employed) using the Khan and Lewis (1984) procedure.
(2) *The Frenchay Dysarthria Assessment* (Enderby 1980) which provides a profile displaying the characteristics of a subject's speech. Various profile patterns have been suggested to represent different types of dysarthria.
(3) A connected speech sample was obtained using a picture stimulus. The picture was the 'I Wonder Card: W-2' from the *Peabody Language Development Kit* (Dunn, Horton and Smith 1968). Each child was asked, 'What will happen next?' Data was recorded on a Revox B77 tape recorder using a microphone distance of one metre. The presence or absence of the ten most prominent features of ataxic dysarthria as defined by Darley, Aronson and Brown (1969) was determined by two independent observers (both qualified speech pathologists) with 100 percent agreement.

Each subject was administered one of the following three language tests as determined by their age at the time of testing:

(1) Test of Language Development Primary (TOLD-P) (Newcomer and Hammill 1982).
(2) Test of Language Development Intermediate (TOLD-I) (Hammill and Newcomer 1982).

(3) Test of Adolescent Language 2 (TOAL-2) (Hammill, Brown, Larsen and Wiederholt 1987).

The above series of tests was chosen to accommodate the large age range covered by the subjects while still allowing some comparisons to be made between subjects of different ages. The TOLD-P provides normative data for children 4 years to 8 years 11 months, the TOLD-I considers children 8 years 6 months to 12 years 11 months and the TOAL-2 permits the assessment of individuals aged 12 years to 18 years 5 months.

Each of the language tests provides an overall language quotient as well as quotients for listening and speaking. The TOLD-P and TOLD-I then give quotients for semantics and syntax while the TOAL-2 considers reading and writing skills. The quotients allow objective intra-subject and inter-subject comparisons to be made. The quotients obtained can then be labelled 'superior' through to 'poor'. Standard scores and percentiles can also be obtained for each subtest. The quotients, standard scores and percentiles can be clearly displayed on the profiles provided. Thus, children of different ages can be compared using the above test series.

All subjects were also administered each of the following subtests of the Clinical Evaluation of Language Functions (CELF) (Semel and Wiig 1982):

(1) Subtest 7—Producing Word Series
(2) Subtest 8—Producing Names on Confrontation
(3) Subtest 9—Producing Word Associations.

The speed and accuracy of language retrieval and production can be screened using these timed components of the CELF.

Case reports

Case 1

Subject 1 was admitted to hospital at the age of 3 years 9 months. He was clumsy, had been irritable for two days and had experienced a mild weight loss. A neurological examination indicated bilateral papilloedema and incoordination to be the only abnormalities. A CT scan performed on admission revealed moderate hydrocephalus with dilation of the third and lateral ventricles associated with a mass lesion in the foramen magnum and fourth ventricles. A ventriculoperitoneal shunt was inserted and a posterior fossa craniotomy performed, resulting in the diagnosis of a medulloblastoma. A rapid recovery was reported and no immediate complications post-surgery were experienced. Mutism following surgery was not recorded. Subject 1 underwent a course of radiotherapy to the whole brain and spinal cord.

A CT scan performed 22 months post-surgery showed the presence of calcification in the temporal fossa, posterior temporal regions and frontal lobes (figure 1) consistent with the effects of radiotherapy.

On assessment 2 years 5 months post-surgery, Subject 1 presented as an alert, cooperative 6-year-old child who was still attending pre-school as his teacher believed he was not yet ready for Grade 1.

Prior to the completion of the test battery, Subject 1 experienced haemorrhaging into the fourth ventricle and a left temporo-parietal infarct. Only the Frenchay Dysarthria Assessment was not completed prior to this incident.

Speech: The Fisher-Logemann Test of Articulation Competence revealed the

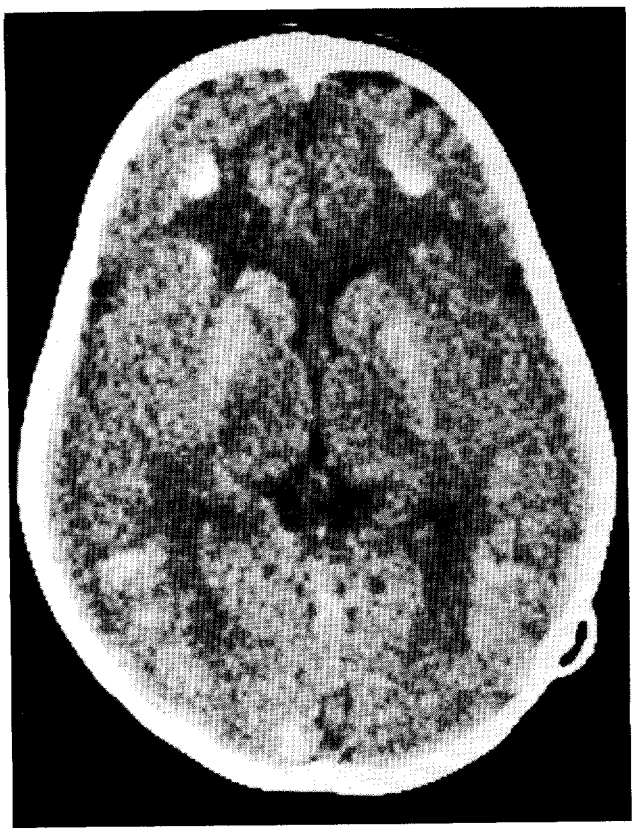

Figure 1. Case 1: post-operative CT scan showing calcification in the temporal fossa, posterior temporal regions and frontal lobes. (Note: the left hemisphere is located on the right side of the figure.)

presence of immature articulation patterns. The phonological processes present included stopping, post-vocalic devoicing, and syllable reduction. All of these processes should have been suppressed by age 5 years (Grunwell 1982).

Language: The language quotients obtained on either the TOLD-P, TOLD-I or TOAL-2 for all of the tumour cases are shown in table 1.

Subject 1 achieved below average scores (i.e. standard score = 6, mean = 10, standard deviation = 3) on the TOLD-P in the subtests of expressive semantics (Oral Vocabulary Subtest), syntactic comprehension (Grammatical Understanding) and expressive syntax (Sentence Imitation). Scores for the areas of receptive vocabulary and auditory discrimination were within normal limits. It can be seen from table 1 that Subject 1 obtained a below average Overall Language Quotient and below average quotients for Speaking and Syntax. Other language quotients were within normal limits.

Of the three CELF subtests administered, Producing Word Associations was performed above criterion in comparison to normative data provided in the test manual. Subject 1 did not know the days of the week or the months of the year in order to complete the Producing Word Series task and was not familiar with the colours and shapes included in the Producing Names on Confrontation subtest. Therefore, he scored below criterion on those subtests.

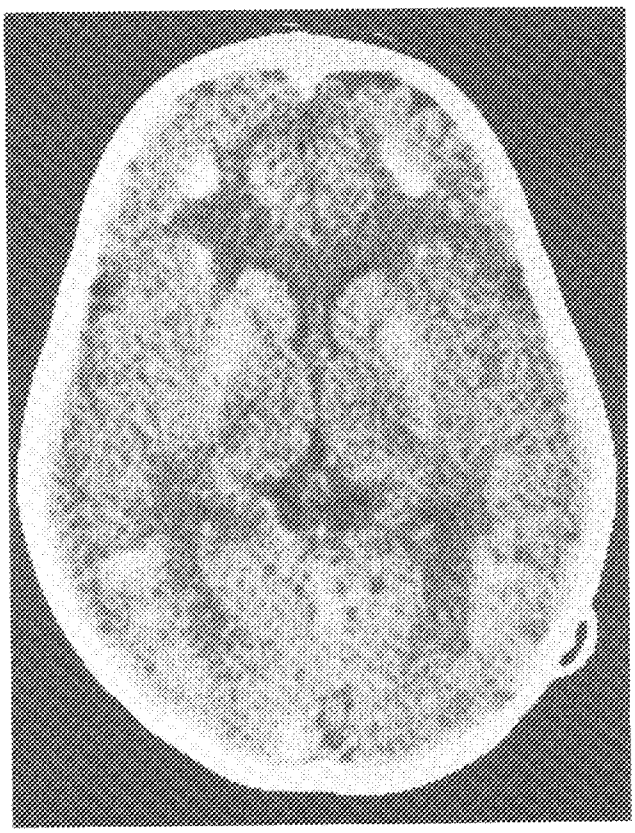

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Table 1. Language quotients obtained by Subjects 1–6 on the Test of Language Development-Primary (TOLD-P), Test of Language Development-Intermediate (TOLD-I) and Test of Adolescent Language-2 (TOAL-2).

TOLD-P	Subject	Language Quotients				
		LQ	LI	SP	SE	SY
	1	81*	91	76*	91	76*
	2	54*	61*	76*	61*	76*
	3	97	94	100	100	96
TOLD-I	Subject	Language Quotients				
		LQ	LI	SP	SE	SY
	4	105	100	109	94	113
TOAL-2	Subject	Language Quotients				
		ALQ	LI	SP	RE	WR
	5	98	97	109	88*	100
	6	NC	NC	103	NC	NC

LQ, Overall Language Quotient; LI, Listening Quotient; SP, Speaking Quotient; SE, Semantics Quotient; SY, Syntax Quotient; ALQ, Adolescent Language Quotient; RE, Reading Quotient; WR, Writing Quotient; NC, Not Completed.
*Denotes below the normal range (TOLD-I and TOLD-P = 85–115; TOAL-2 = 90–110)

Overall, the language tests indicated that Subject 1 has a mild language impairment with particular difficulties being experienced in the areas of expressive semantics, and expressive and receptive syntax.

Discussion of Case 1: Although Subject 1 had experienced a cerebellar lesion, dysarthric speech was not observed (based on perceptual assessment of the connected speech sample) in the period immediately post-surgery up until such time that a fourth ventricle haemorrhage and left temporo-parietal infarct occurred.

Despite the posterior fossa site of the medulloblastoma, a language deficit was detected. The presence of calcification in the temporal fossa, posterior temporal regions and frontal lobes was identified by CT scanning in 1986 (figure 1). Several authors have linked the occurrence of intracerebral calcifications in children with the cranial irradiation and/or chemotherapy administered in cases of childhood cancer (Lee and Suh 1977, Giralt, Gil, Borderas, Oliveros, Gomez-Pereda, Pardo, Martinez-Ibanez and Raichs 1978, Hodges and Smith 1983, Pearson, Campbell, McAllister and Pearson 1983). Thus, it is possible that the language deficit exhibited by Subject 1 represents a component of an overall intellectual or cognitive deficit resulting from the calcification in the frontal and temporal lobes. The impaired academic abilities demonstrated by Subject 1 and his poor performance on the CELF (subtests 7 and 8) would further indicate the presence of an overall cognitive deficit. It is probable that the observed calcification is the product of the radiotherapy undergone by Subject 1 when he was 3 years 9 months of age. Residual effects of the cortical compression associated with hydrocephalus may also be another factor contributing to the occurrence of the language disturbance.

It is difficult to assess whether the language problems observed in Subject 1 reflect an acquired aphasia or an interruption to the normal developmental process of language acquisition, as the reduced syntactic ability which has been observed in

children with acquired aphasia (Alajouanine and Lhermitte 1965, Satz and Bullard-Bates 1981, Carrow-Woolfolk and Lynch 1982, Van Dongen *et al.* 1985) is also frequently seen in cases of developmental language impairments (Aram and Nation 1981).

Case 2

Subject 2 was an 8 year 8 month-old male. He was admitted to hospital at the age of 2 years 7 months. On admission he was 'talking well' and developing normally but was listless, uncoordinated and vomited once a day. A neurological examination revealed bilateral papilloedema and dysfunction of the eighth cranial nerve. No other neurological abnormalities were recorded.

A CT scan performed on admission showed a midline tumour in the posterior fossa arising from the cerebellum. It measured 3·5 cm in anterior–posterior diameter. Enlarged lateral and third ventricles due to obstructive hydrocephalus were also reported. An ependymoma was diagnosed.

A ventriculoperitoneal shunt was inserted to alleviate the hydrocephalus and a posterior fossa craniotomy was performed. Subject 2 had a left facial palsy following surgery which had not resolved at the time of the present speech and language assessment. He was discharged from hospital 10 weeks later following a course of radiotherapy which involved a total dose of 4000 rad to the whole brain and spinal cord. Subject 2 spent a prolonged period (27 days) in the intensive care unit and was mute for 6 months following surgery. After this he made a particularly slow but uneventful recovery.

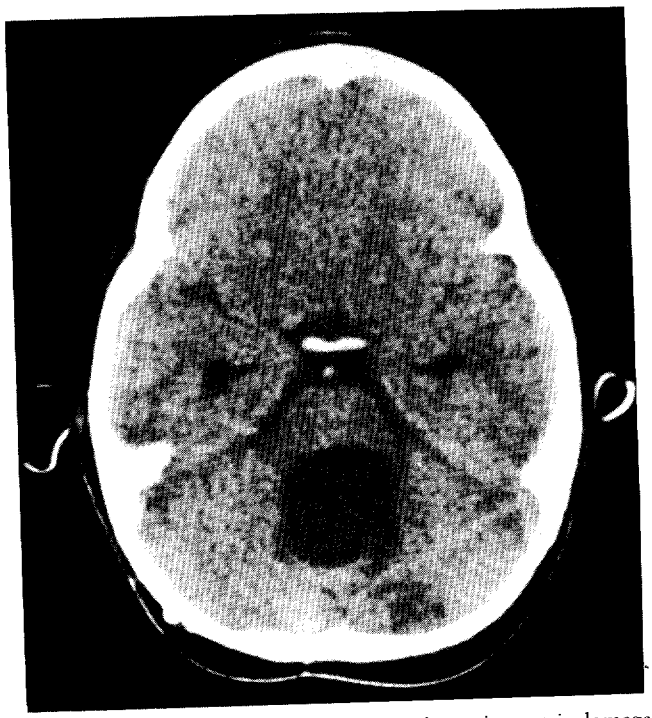

Figure 2. Case 2: post-operative CT scan demonstrating dramatic ventriculomegaly which is most marked in the fourth ventricles due to the tumour resection. (Note: the left hemisphere is located on the right side of the figure.)

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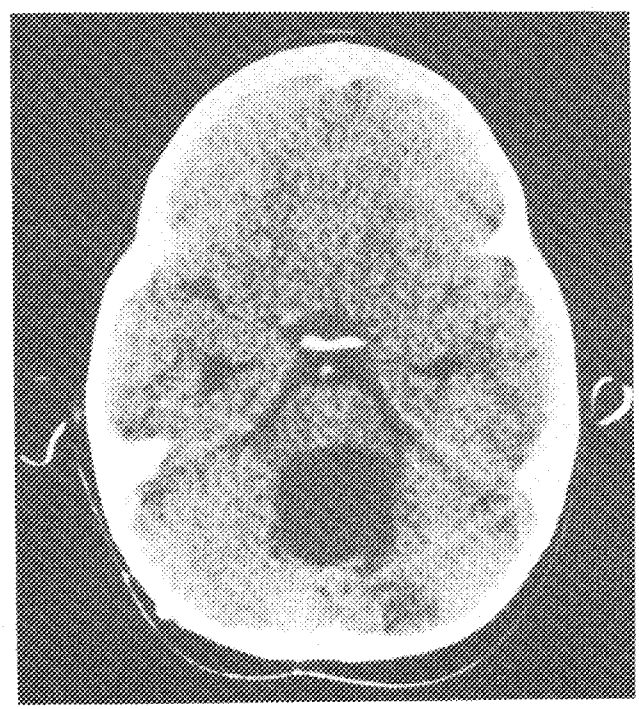


Figure 2. Case 2: post-operative CT scan demonstrating dramatic ventriculomegaly which is most marked in the fourth ventricles due to the tumour resection. (Note: the left hemisphere is located on the right side of the figure.)

A CT scan performed three years post-surgery demonstrated dramatic ventriculomegaly which was most marked in the fourth ventricles because of the fourth ventricle tumour resection (figure 2).

At the time of assessment for the present study, Subject 2 was 8 years 8 months old. He presented as a happy cooperative child who was enjoying Grade 1 at a small country school where he was receiving remedial instruction twice a week. Due to his ataxic gait, he required assistance when walking and wore a helmet to protect his head from frequent falls.

Speech: The Fisher-Logemann Test of Articulation Competence showed the presence of a number of inconsistent phoneme productions and the retention of phonological processes, e.g. cluster reduction, syllable reduction, stopping, backing to velars, progressive assimilation and regressive assimilation. By his age, these processes and articulation errors should have been eliminated (Grunwell 1982).

The Frenchay Dysarthria Assessment indicated a mixed Ataxic-Flaccid Dysarthria. Uncoordination was apparent in the lip and tongue movements as well as in the lack of laryngeal control. The presence of a left facial palsy resulted in lip and jaw asymmetry at rest and restricted the range of lip and jaw movements on the left side. Tongue movements were also limited in range. Five of the 10 ataxic dysarthric chracteristics (Darley *et al.* 1969) were present including imprecise consonants, excess and equal stress, irregular articulatory breakdowns, prolonged phonemes and slow rate. A lack of volume control was also detected. Overall, the mixed dysarthria made Subject 2 largely unintelligible.

Language: A severe language delay was indicated by the TOLD-P with all subtests and quotients falling below the normal range (see table 1). All three subtests of the CELF were scored below criterion. Subject 2 did not know the days of the week or the months of the year in order to complete the Producing Word Series task and his dysarthria limited the speed at which he was able to complete the Producing Names on Confrontation and Producing Word Associations subtests.

Subject 2 used telegraphic speech in the sentence imitation subtest of the TOLD-P, reproducing mainly content words. In spontaneous speech, utterances between five and eight words in length were unintelligible. Subject 2 deliberately reduced such utterances to one or two words to enable the listener to comprehend his meaning. His receptive language skills (approximately 6-year level) appeared to be in line with his academic functioning as a Grade 1 child as reported by his mother. Therefore, although Subject 2 was impaired in all areas of language, his severe mixed dysarthria contributed to his poor expressive language skills.

Discussion of Case 2: While Subject 2's facial palsy would account for some features of the observed dysarthria (limited range of lip, tongue and jaw movements), damage to the cerebellum is the most likely cause of his imprecise consonants, excess and equal stress, irregular articulatory breakdowns, prolonged phonemes and slow rate. Poor coordination of speech and non-speech oral movements and a lack of laryngeal and volume control is also consistent with damage to the cerebellum. The CT scan performed three years post-surgery demonstrated the presence of the dramatic ventriculomegaly which was most marked in the fourth ventricle because of the tumour resection. It is possible that such a residual feature contributes to the continuing severity of the dysarthria.

Subject 2 exhibited a global language deficit involving all aspects of reception and expression. In the light of this child's delayed academic functioning, a full neuropsychological assessment would be required before the proper interpretation of

these observed language results could be made, as cognitive deficits may also be present. Consideration of the tumour site does not lead to the prediction of a language disability, however, as has been mentioned, there are features secondary to the occurrence of a posterior tumour that must be considered.

Although the presence of intracranial calcification was not evident in the CT scan performed three years post-surgery, calcification has been found to be a delayed reaction occurring between 5 and 14 years post-treatment (Giralt *et al.* 1978, Hodges and Smith 1983, Pearson *et al.* 1983, Lichtor, Wollmann and Brown 1984).

Cerebral radionecrosis is another late effect of cranial irradiation that has been documented. It refers to morphological changes in the brain tissue which are indicative of cell death and has been linked to the dose, time and fractionation of radiotherapy (Marks, Baglan, Prassad and Blank 1981, Marks and Wong 1985). In addition, cerebrovascular disease has been documented in children who have experienced radiotherapy (Painter, Chutorian and Hilal 1975, Wright and Bresnan 1976).

Despite the lack of evidence of cortical abnormalities in his most recent CT scan, the presence of cerebral radionecrosis or radiation-induced cerebrovascular disease cannot be ruled out as possible contributors to the continuing speech and language disorders exhibited by Subject 2. Further, a considerable degree of hydrocephalus was noted at the time of admission, therefore, damage resulting from prolonged cortical compression may be another factor influencing language functioning.

Case 3

Subject 3 had a posterior fossa ependymoma removed when he was 2 years 1 month old. The tumour measured 3·4 cm in diameter and was situated in the vermis passing towards the left side and downwards into the brainstem (figure 3). A ventriculo-peritoneal shunt was also inserted. Mutism was not reported to have occurred post-surgery. No post-surgical complications were experienced. Both radiotherapy and chemotherapy followed the surgical procedures.

Three years post-surgery, Subject 3 received speech therapy for the remediation of the phonological processes of cluster reduction, final consonant deletion and progressive assimilation which were described as developmental in nature and not related to his surgical condition. There was no evidence of dysarthria at that time and both receptive and expressive language skills were described as above average.

Subject 3 was assessed for the purposes of the present study at the age of 8 years 10 months. He presented as a happy, energetic child who was small for his age.

Speech: The Fisher-Logemann Test of Articulation indicated the presence of the phonological processes of progressive assimilation and syllable reduction. The articulation errors and phonological processes observed represent speech patterns which should have been resolved by this stage (Grunwell 1982, Ingram 1980).

Limitations in lip and tongue movements were observed during the Frenchay Dysarthria Assessment. The reduced range and speed of movements had only a mild influence on speech which did not detract from intelligibility but contributed to the immature speech pattern created by the sound substitutions listed above. Although none of the 10 features described by Darley *et al.* (1969) as characteristic of ataxic dysarthria was present, distinct hypernasality was noted by both observers.

Language: All subtests and quotients of the TOLD-P were within the normal range (see table 1). The Producing Word Associations subtest of the CELF was below

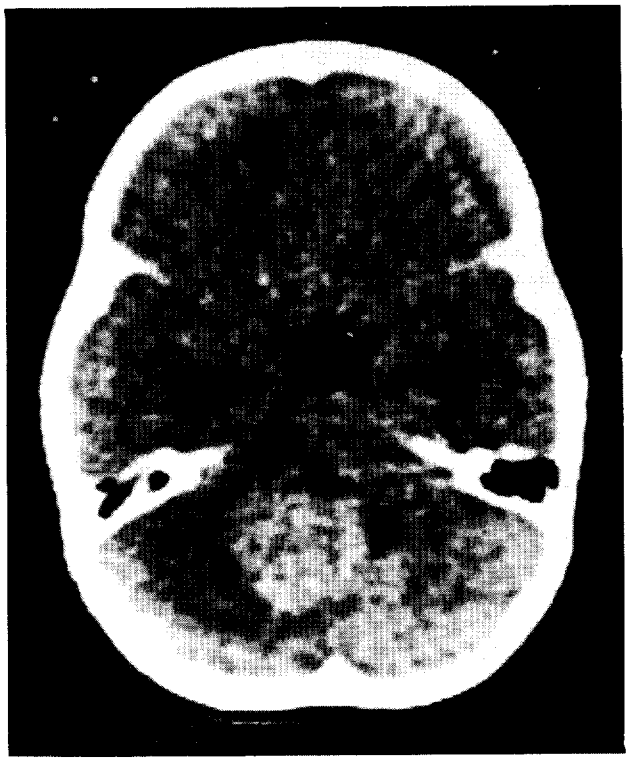


Figure 3. Case 3: pre-operative CT scan showing posterior fossa ependymoma situated in the vermis and passing towards the left side. (Note: The left hemisphere is located on the left side of the figure. This scan is the other way round from those shown in figures 1, 2, 4 and 5).

criterion suggesting the presence of a word retrieval problem since both picture and oral vocabulary scores were normal.

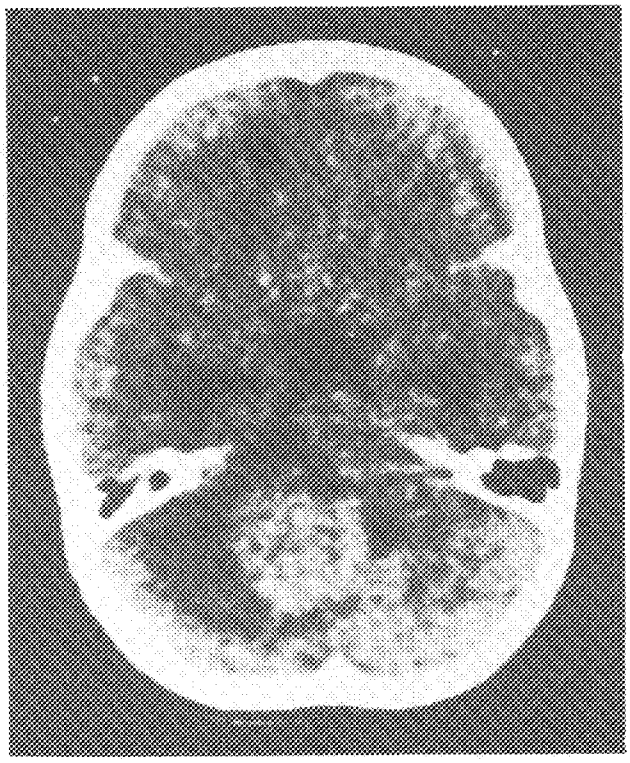
Discussion of Case 3: Subject 3 exhibited some articulatory/phonological errors in his speech and reduced lip and tongue scores were obtained on the Frenchay Dysarthria Assessment. His overall intelligibility, however, was not affected.

The overall language abilities of Subject 3 are within normal limits, however, word retrieval problems were noted on his performance on the CELF. As discussed previously, delayed effects of irradiation and/or chemotherapy such as intracranial calcification, radionecrosis or cerebrovascular disease could be related to these observations, as could the residual effects of hydrocephalus.

The suggested word retrieval difficulties, in the absence of other language deficits, may have implications for future educational success as higher grades of schooling are attempted and, hence, should be monitored. The large latency periods between the completion of radiotherapy and the onset of neurological symptoms recorded by several researchers (Lee and Suh 1977, Giralt *et al.* 1978, Marks *et al.* 1981, Kearsley 1983, Pearson *et al.* 1983) as well as the progressive nature of some delayed reactions, also have implications for the long term monitoring required for these patients.

Case 4

Subject 4 was admitted to hospital at the age of 6 years 8 months. A history of un-



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Case 4

Subject 4 was admitted to hospital at the age of 6 years 8 months. A history of un-

coordination, papilloedema and vomiting was reported. A CT scan performed one day after admission revealed a large enhancing tumour in the midline of the posterior fossa extending up into the superior vermis (figure 4). It was slightly larger on the left than the right. A considerable amount of surrounding oedema was observed as well as compression of the fourth ventricle with hydrocephalus. A ventriculoperitoneal shunt was inserted to relieve the associated hydrocephalus. A posterior fossa craniotomy was then performed and complete tumour resection was possible. Final

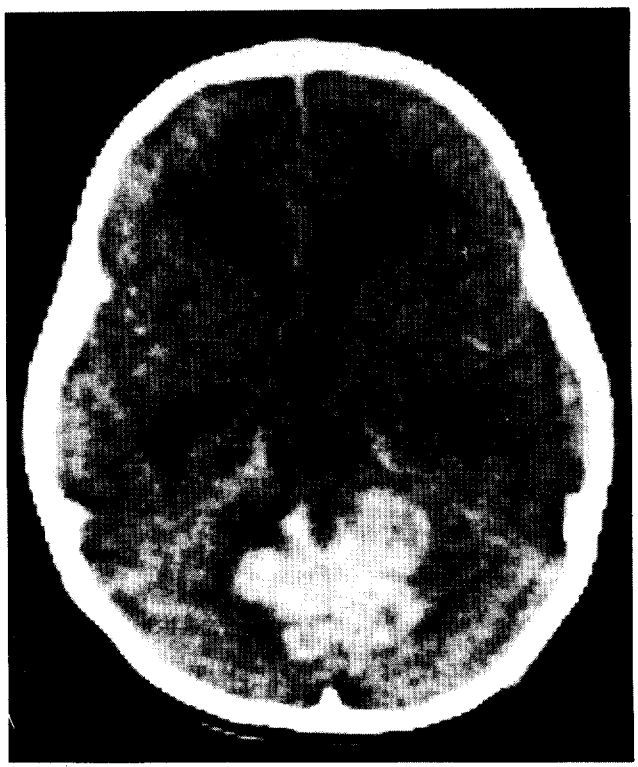


Figure 4. Case 4: pre-operative CT scan showing a large enhancing astrocytoma in the midline of the posterior fossa. (Note: The left hemisphere is located on the right side of the figure.)

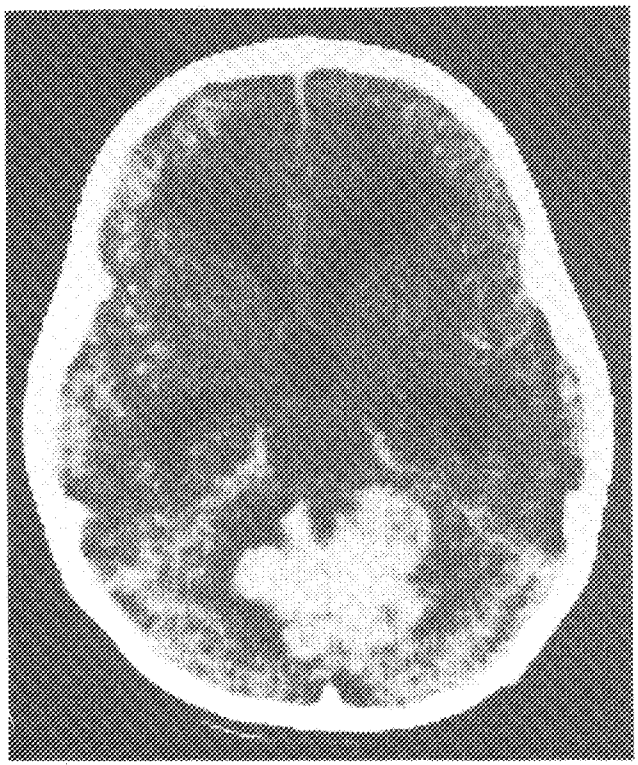
diagnosis was that of a solid cerebellar astrocytoma. As a low grade astrocytoma was diagnosed, radiotherapy was not required. Mutism post-surgery was not reported.

At the time of speech/language assessment, Subject 4 presented as a happy, alert 11 year-old who expressed enthusiasm towards school and her many extra-curricular activities. Her first Grade 7 report depicted a student receiving a grade of 'A' for all subjects except Mathematics for which a 'B' was obtained.

Speech: The Fisher-Logemann Test of Articulation Competence revealed an absence of articulation errors in single word productions.

The profile obtained from the Frenchay Dysarthria Assessment demonstrated a very slight deviation of the resting tongue to the right and while lateral tongue movement appeared accurate and complete, it was a little slow at five cycles in four seconds. The completion of this task within three seconds was considered to be within normal limits for the adults tested by Enderby (1980). Abnormalities were not observed in the other parameters measured.

coordination, papilloedema and vomiting was reported. A CT scan performed one day after admission revealed a large enhancing tumour in the midline of the posterior fossa extending up into the superior vermis (figure 4). It was slightly larger on the left than the right. A considerable amount of surrounding oedema was observed as well as compression of the fourth ventricle with hydrocephalus. A ventriculoperitoneal shunt was inserted to relieve the associated hydrocephalus. A posterior fossa craniotomy was then performed and complete tumour resection was possible. Final



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Language: Subject 4 obtained average or above average scores on all five subtests of the TOLD-I. The Listening, Speaking, Semantics and Syntax Quotients all fell within normal limits. The three subtests administered from the CELF were all above criterion.

Discussion of Case 4: Despite the tumour, hydrocephalus and surgery experienced, Subject 4 did not demonstrate any residual speech or language impairments. The factors which may be related to Subject 4's favourable status include the low grade malignancy of the astrocytoma, the complete resection of the tumour and the lack of post-surgical chemotherapy and radiotherapy. The large size of the astrocytoma (see figure 4) and the resultant tissue compression and hydrocephalus that no doubt occurred, have not created the deficits that were observed in the previous three cases where large tumours, hydrocephalus and tissue compression also occurred. However, Cases 1, 2 and 3 all experienced radiotherapy and/or chemotherapy in their treatment programmes.

Case 5

Subject 5 was a 15 year 4 month old male who was admitted to hospital at the age of 13 years. He had a history of headaches, a slight ataxia and a slight uncoordination of the left hand. A CT scan performed on admission showed an infiltrating low density mass lesion in the cerebellum (figure 5). It was in the midline and slightly to the left of the midline compressing the fourth ventricle from its dorsal aspect. Marked hydrocephalus with dilation of the third and lateral ventricles was also present. A ventriculoperitoneal shunt was inserted and one week later the tumour was partially removed. Diagnosis was that of an ependymoma. Immediately following surgery, truncal ataxia was observed but speech was described as clear. Recovery was rapid and Subject 5 was discharged six days later. A course of radiotherapy followed in which a total dose of 5000 rad was delivered to the whole brain and spinal cord. A CT scan performed in 1985 showed residual ependymoma in the superior vermian cistern and mild ventromegaly.

Subject 5 is currently in Grade 10 and intends to complete his secondary education. His parents describe him as 'average' in his studies.

Speech: Subject 5 did not exhibit any articulation errors in the Fisher-Logemann Test of Articulation Competence. The Frenchay Dysarthria Assessment detected only a slight limitation in palatal movement and an associated hypernasality. Hypernasality was also perceived in both parents' speech which suggests this feature may be familial. No dysarthria was detected.

Language. The TOAL-2 showed an average level of oral language mastery (see table 1) with Reading/Grammar falling below the normal range. All three subtests of the CELF were above criterion.

Thirteen months post-surgery, Subject 5 was assessed by a clinical neuropsychologist who reported the following findings:

(1) Mild impairment of memory for verbally presented material and for new learning in this modality. Following a half hour delay, he had difficulty spontaneously recalling a passage which he had earlier reported but could recall the same when cued. This suggests that information is being stored but is not readily accessible to spontaneous retrieval.

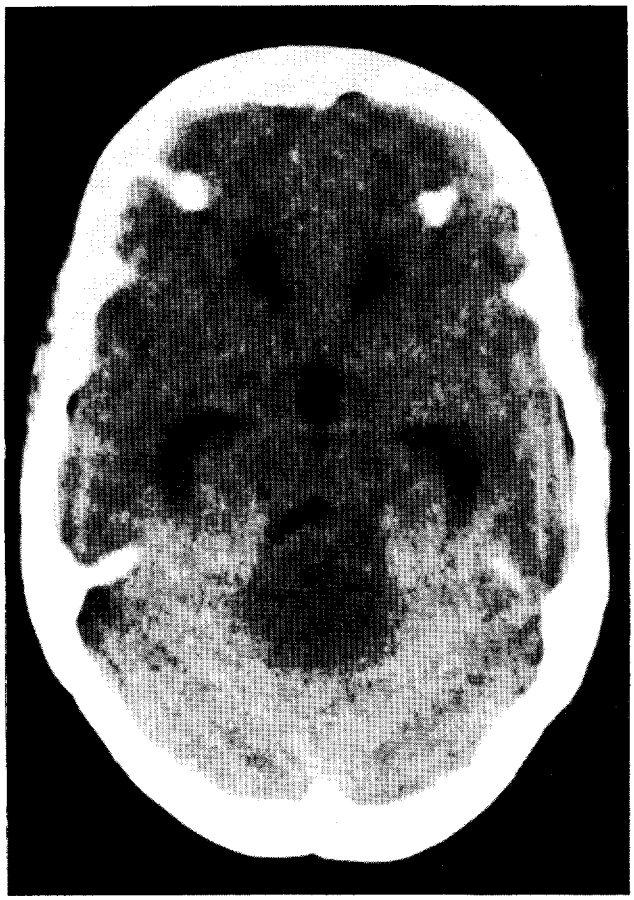


Figure 5. Case 5: pre-operative CT scan showing infiltrating, low density mass lesion in the cerebellum. (Note: The left hemisphere is located on the right side of the figure.)

(2) Mild to moderate impairment of memory for visually presented material and for learning in this modality.
(3) Mild word finding difficulty was evident on testing.

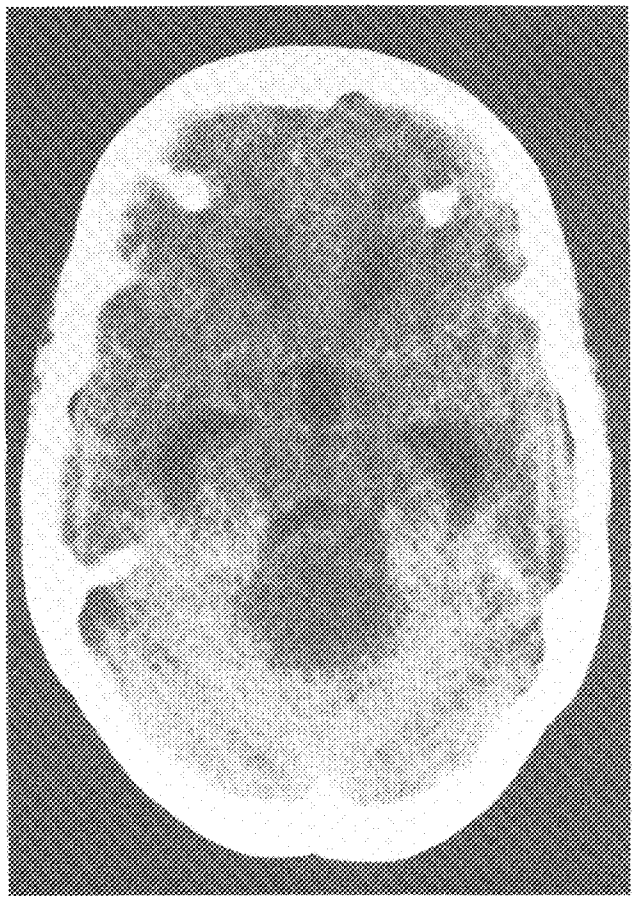
The Listening/Grammar subtest of the TOAL-2 requires the subject to listen to three sentences and choose the two which are closest in meaning. Subject 5 demonstrated difficulty remembering the sentences he had heard. Difficulty was also experienced repeating the sentences in the Speaking/Grammar subtest.

Discussion of Case 5. Despite the surgery, hydrocephalus and radiotherapy experienced, and the presence of residual ependymoma and mild ventriculomegaly, Subject 5 exhibited only relatively mild speech and language deficits.

Language skills were shown to be adequate with the exception of reading ability. Reduced memory skills were also evident, reflecting a cognitive impairment possibly resulting from the effects of either radiotherapy or hydrocephalus.

Case 6

Subject 6 was admitted to hospital at the age of 12 years 1 month with a history of headache and vomiting. On examination, he was alert and orientated with a normal



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Language skills were shown to be adequate with the exception of reading ability. Reduced memory skills were also evident, reflecting a cognitive impairment possibly resulting from the effects of either radiotherapy or hydrocephalus.

Case 6

Subject 6 was admitted to hospital at the age of 12 years 1 month with a history of headache and vomiting. On examination, he was alert and orientated with a normal

pulse rate and blood pressure. He had bilateral gross papilloedema and a severe ataxic gait when his eyes were closed but compensated fairly well with his eyes open. Tremor of both hands was also noted. A CT scan indicated the presence of a cerebellar tumour 5 cm in diameter situated in the midline and extending upwards behind the third ventricle. The tumour was diagnosed as a juvenile astrocytoma.

Three operations involved the insertion of a ventriculoperitoneal shunt, removal of the tumour and removal of an extradural haematoma. Following insertion of the shunt, Subject 6 was drowsy and had a left facial and upper limb paresis. There was no improvement before the posterior fossa craniotomy 13 days later. The tumour was completely removed. Three days later Subject 6 became cyanotic due to a collapsed left lung and had to be re-intubated. One week after this incident, an extradural haematoma was evacuated which resulted in improved consciousness. The hemiparesis resolved but Subject 6 remained ataxic.

Subtotal resection of recurrent posterior fossa astrocytoma was performed two years after the initial surgery. A CT scan, performed one year prior to speech and language assessment, revealed a small recurrent tumour in the posterior fossa.

Subject 6 was 16 years 10 months of age when assessed for speech and language abilities for the purposes of the present study. He was able to walk short distances with assistance but preferred to use a wheelchair. He tired quickly, becoming irritable and easily frustrated and his coordination and hearing were deteriorating as the need for further surgery approached.

Speech: All phonemes in the single word productions of the Fisher-Logemann Test of Articulation Competence were produced accurately although some phoneme prolongations were evident. The Frenchay Dysarthria Assessment resulted in a profile resembling that given in the manual as characteristic of ataxic dysarthria. All oral movements were observed to be slow and lacking in control.

Six of the ten features characteristic of ataxic dysarthria (Darley *et al.* 1969) were present in the connected speech sample. These included imprecise consonants, excess and equal stress, harsh voice, prolonged phonemes, prolonged intervals and slow rate. Pitch breaks, variable pitch, a lack of volume control and explosive onsets were also evident.

Language: Subject 6 was only able to complete three subtests of the TOAL-2, these being the Listening/Grammar (standard score = 10), Speaking/Vocabulary (standard score = 10), and Speaking/Grammar (standard score = 11) subtests. Scores obtained on all three of these subtests were within the normal range. Poor vision prevented him attempting the Listening/Vocabulary, Reading/Vocabulary, Reading/Grammar, Writing/Vocabulary and Writing/Grammar subtests. Limb ataxia also inhibited his writing ability.

The Producing Word Series and Producing Word Associations tasks of the CELF were above criterion. Producing Names on Confrontation was not attempted. Overall, the language tests completed did not suggest the presence of a language deficit. Further testing, however, would be necessary before the possibility of impaired language abilities could be definitely excluded.

Discussion of Case 6. Subject 6 exhibited severe ataxia and dysarthria which could be attributed to his original cerebellar lesion, further surgery for resection of recurrent astrocytoma and recurrent tumour present on assessment. While the dysarthria observed was characterized by six of the ten most frequent features of ataxic dysarthria (Darley *et al.* 1969), pitch breaks, variable pitch and a lack of volume control rather than monopitch and monoloudness were noted by both assessors. Explosive onsets

were also recorded while irregular articulatory breakdowns were not evident and vowels were prolonged rather than distorted. The apparent lack of a language disturbance may reflect the absence of radiotherapy as part of the post-surgical treatment program.

Summary and conclusions

Table 2 summarizes the major personal, medical, speech and language characteristics of each subject.

Speech disorders were detected in four of the six posterior fossa tumour cases with two subjects exhibiting dysarthria with characteristics of the ataxic type and two demonstrating immature speech patterns. Both cases of ataxic dysarthria occurred subsequent to a period of mutism immediately post-surgery suggesting that mutism post-surgery is indicative of a poor prognosis for speech abilities in the long term. In support of this suggestion, several other cases of ataxic dysarthria occurring subsequent to mutism following surgery to remove cerebellar tumours have also been reported in the literature (Rekate *et al.* 1985, Volcan *et al.* 1986). In one subject in the present study, a flaccid component of a predominantly ataxic dysarthria was noted and attributed to damage occurring during surgical removal of the tumour.

Table 2. Personal, medical and speech/language characteristics of Subjects 1–6.

	Subjects					
	1	2	3	4	5	6
Sex	M	M	M	F	M	M
Age at assessment*	6:2	8:8	8:10	11:7	15:4	16:10
Tumour type	Mb	Ep	Ep	SAs	Ep	JAs
Time post-surgery*	2:5	6:1	6:9	4:9	2:4	4:9
Age at surgery*	3:9	2:7	2:1	6:10	13:0	12:1
Complete/ partial removal	C	C	NA	C	P	C
Shunt/s yes/no	yes	yes	yes	yes	yes	yes
revisions	0	2	0	0	0	1
Radiotherapy yes/no	yes	yes	yes	no	yes	no
Complications	no	no	no	no	no	cyanotic post-surgery tumour recurrence
Mute post-surgery	no	yes	no	no	no	yes
Speech	d	AD	d	−	−	AD
Language	+	++	+	−	+	−

Mb, medulloblastoma; Ep, ependymoma; SAs, solid astrocytoma; JAs, juvenile astrocytoma.
*years:months; C, complete tumour removal; P, partial tumour removal; NA, not available; +, mild abnormality detected; ++, moderate-severe abnormality detected; −, no abnormality detected; d, developmental disorder; AD, ataxic dysarthria.

Using an adult dysarthria assessment and a check list of ataxic dysarthric characteristics, which have been observed in adults with cerebellar lesions, allowed the diagnosis and description of the two cases of acquired childhood dysarthria observed in the present study. However, of the ten characteristics determined by Darley *et al.* (1969), monopitch, monoloudness and distorted vowels were not detected in the experimental group. Rather than monopitch and monoloudness, both pitch and vocal volume showed sudden uncontrollable changes, probably as an outcome of cerebellar dysmetria. Inconsistency and unpredictability of pitch changes in a patient with ataxic dysarthria was also noted by Kent and Netsell (1975) suggesting that prosodic abnormalities in the form of monopitch and monoloudness may not be important features of ataxic dysarthria.

Language impairments were observed in four out of the six cases reported. Only Subjects 4 and 6 exhibited no noticeable language deficits, these two cases also being the only two who had not received radiotherapy post-surgery. In one case the observed language disorders appeared to be related to the presence of calcification in the frontal and temporal lobes.

The preliminary findings reported indicate that dysarthria and language impairment are not an inevitable outcome of surgery to remove posterior fossa tumours in children. However, in some cases, speech and/or language deficits do occur. In particular, the occurrence of muteness immediately post-surgery would appear to indicate a poor prognosis for speech abilities. These children usually exhibit dysarthria in the long term. Likewise, children who undergo radiotherapy post-surgery appear to have a greater chance of long term language impairment than those who do not. Although it is recognized that radiotherapy may be essential for the long term survival of children who have undergone surgery to remove posterior fossa tumours, the medical team needs to be aware of the possible long term effects that this treatment may have on language abilities.

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