Paraplegia (1977-78), **15**, 262-273

INTRASPINAL NEOPLASMS IN CHILDREN*

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Abstract. Twenty-nine primary intraspinal neoplasms in children observed between 1936 and 1975 in Connecticut are reviewed. Most of them were gliomas: 45 per cent astrocytoma, 24 per cent ependymal neoplasm, 10 per cent glioblastoma multiforme and 7 per cent glioma. Symptoms, physical findings and therapy are reviewed.

Key words: Intraspinal neoplasms; glioma; children.

Introduction

NEOPLASMS of the central nervous system are less common among children than among adults. Further, while the ratio of intracranial to intraspinal neoplasms in adults is about 5 : 1, in children the ratio is about 20 : 1 (Bailey, 1936), intraspinal tumours being much less often found. Series of these infrequently occurring tumours of the spinal cord have been reported, most based on the experience of one surgeon or one institution (Ingraham, 1938; Anderson & Carson, 1953; Dodge *et al.*, 1956; Rand & Rand, 1960; Coxe, 1961; Slooff *et al.*, 1964; Arseni *et al.*, 1967; Matson, 1969; Grote *et al.*, 1975). The purpose of the present study is to review and to analyse the cases of primary intraspinal neoplasm recorded in a population-based tumour registry in a 40-year period. Because the registry records the experience of an entire state, comparisons of this series with the simultaneous series of intracranial tumours in children (Farwell & Dohrmann, 1976; Dohrmann & Farwell, 1976) is possible.

Patients and Methods

The files of the Connecticut Tumor Registry were searched for primary intraspinal neoplasms, diagnosed in patients less than 20 years of age in Connecticut during the years 1936-75. All newly diagnosed cases of cancer are reported to the Registry and lifelong follow-up is obtained (Connelly *et al.*, 1968). Metastatic neoplasms, tumours of nerve roots and tumours of bone as well as vascular malformations were not included. These cases were reviewed by the authors and in some instances the histopathological diagnosis was changed. The resulting series of patients was analysed with respect to histopathological type of tumour, age at diagnosis, year of diagnosis, site of the tumour, presenting symptoms and their duration, presenting physical findings, treatment, and survival. Since there are a number of long-term survivors, survival was calculated through 5 years from diagnosis by standard life-table techniques and recorded as cumulative probability of survival, correcting at each time interval for children still alive at the time of the study but followed for less than 5 years (Armitage, 1971).

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Results

Twenty-nine primary intraspinal neoplasms occurred in children in Connecticut from 1936 through 1975 (Table I). Fourteen were in girls and 15 in boys. The tumours were diagnosed at times fairly evenly distributed throughout the 40-year period, as in Figure 1.

Histopathological type

In Figure 2 is seen the histopathological distribution of the neoplasms. Thirteen, or nearly half, were astrocytomas. Seven (about one-quarter) were ependymal neoplasms; of these, six were ependymomas and one was an ependymoblastoma. There were three cases of intraspinal glioblastoma multiforme. A diagnosis of glioma, not further classified, was made in two patients. One case each of malignant meningoma, chordoma, spongioblastoma, and dermoid occurred.

Location

The intraspinal neoplasms were located throughout the length of the spinal cord, as seen in Figure 3. Thirty-four per cent occurred in the cervical spinal cord, 38 per cent in the thoracic spinal cord, none in the lumbar spinal cord and 28 per cent in the conus/cauda equina region, including the filum terminale. The highest level involved was C2, where one chordoma and one glioma were found. A predilection of certain types of tumour for certain sites was seen. Five of the

TABLE I

Neoplasms of the spinal cord in children

	No.	Cervical	Thoracic	Conus	Male : female	Average age (yr)
All histopathological types	29	10	11	8	14 : 15	11·3
Astrocytoma	13	6	5	2	6 : 7	11·5
Ependymal neoplasm	7	0	2	5	2 : 5	13·3

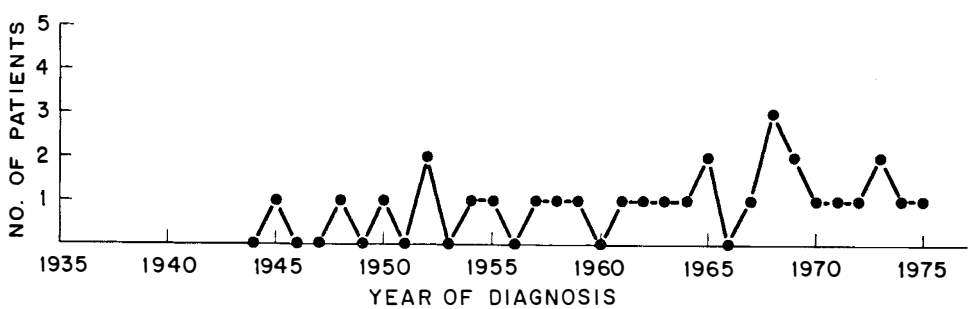


FIG. 1

Year of diagnosis of intraspinal neoplasms in children. Since 1955 the frequency has been fairly constant.

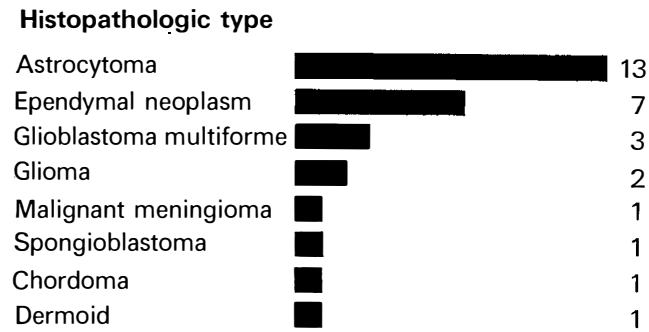


FIG. 2

Histopathological type of primary intraspinal neoplasms. Astrocytoma was the most common neoplasm noted.

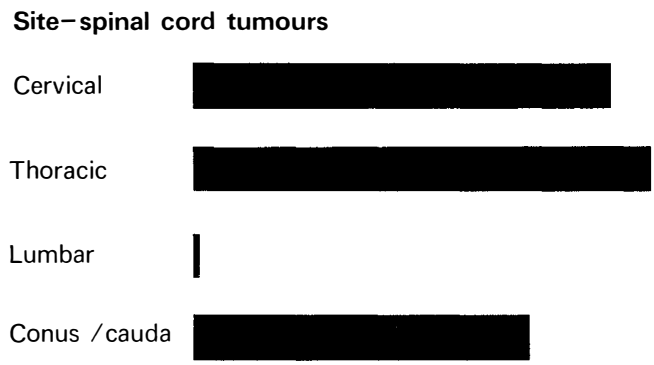


FIG. 3

Site of intraspinal neoplasms. Thoracic tumours were most numerous.

ependymal neoplasms occurred in the conus/cauda equina region and the other two were found at the lower thoracic level. Only two astrocytomas occurred in the filum terminale, however; the majority were located at cervical or thoracic levels.

Age

Twice as many intraspinal neoplasms occurred in children aged 10-19 as in children younger than 10. As shown in Figure 4, the frequency increased in each hemidecade of life. The average age at diagnosis was 11·3 years. An infant of 3 months had a meningioma, and a dermoid was diagnosed in an infant of 7 months.

Symptoms

In more than half the patients, the major presenting symptom was paresis or paralysis (Table II). Forty-six per cent complained of neck or back pain. Difficulty in walking or the noting of a 'limp' occurred in 21 per cent, five with thoracic tumours and one with a conus/cauda equina tumour. Incontinence or urinary urgency were symptoms in 21 per cent of the children, including one with a cervical tumour. Hypesthesia/hypalgesia were noted by another 21 per cent. Pain in an arm or leg was a symptom in children with tumours in various locations.

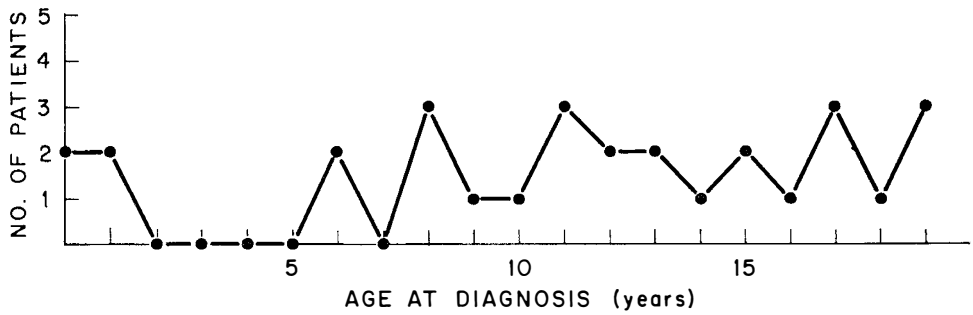


FIG. 4

Age of children with intraspinal neoplasms at diagnosis. Twice as many neoplasms occurred in the second decade as in the first.

TABLE II

Symptoms of children with intraspinal neoplasms

	Overall				
	%	Number	Cervical	Thoracic	Conus/cauda equina
Paresis/paralysis	60	16	7	7	2
Neck/back pain	46	13	6	3	4
'Limp'	21	6	0	5	1
Bladder dysfunction	21	6	1	3	2
Paresthesiae	21	6	3	1	2
Arm/leg pain	21	6	2	1	3

Paraplegia occurred in two children with thoracic tumours and one child with a cervical tumour. The one child with a seizure had a high cervical glioblastoma multiforme. Irritability, as well as paraplegia, occurred in an infant with a thoracic dermoid.

In many instances, the symptoms were already long-standing complaints when the diagnosis of an intraspinal tumour was made. One 8-year-old child had been followed for 7 years for 'progressive neurologic deficit' and had undergone a bladder operation before a diagnosis of cervical astrocytoma was made. An 11-year-old boy had been followed for 9 years for right-leg weakness, and had his limp treated with a back brace for 2 years, before a thoracic astrocytoma was found. A 13-year-old girl had limped and complained of leg weakness for 8 years. A diagnosis of Charcot-Marie-Tooth disease had been made, and she had undergone stabilising surgery on her ankles. In other cases, the initial symptoms did not point to spinal cord disease. One child was admitted with symptoms of lethargy and generalised weakness. A diagnosis of encephalitis was made and subsequently the child was found to have a cervical astrocytoma.

Physical Findings

The physical findings at diagnosis, occurring in more than one child, appear in Table III. Sixty per cent were found to have paresis or paralysis of one or more

TABLE III

Physical findings of children with intraspinal neoplasms

	Overall				
	%	Number	Cervical	Thoracic	Conus/cauda equina
Paresis/paralysis	60	16	7	7	2
Sensory loss	38	10	2	6	2
Meningismus	27	7	4	2	1
Hyperreflexia	23	6	4	2	0
Hyporeflexia	15	4	1	2	1
Ataxia/dysmetria	8	2	2	0	0
Loss of sphincter tone	8	2	0	1	1
Pain on straight leg raising	8	2	0	0	2

extremities. Thirty-eight per cent had some sensory loss, ranging from loss of all sensation below a given level to loss of position sense in one extremity. Meningismus was found in 27 per cent, most with cervical spinal cord tumours; one child had had a subarachnoid haemorrhage. Increased or decreased deep tendon reflexes were found in 23 per cent and 15 per cent, respectively. One child was noted to have kyphoscoliosis.

Treatment

The children received various treatments. All were operated upon at least once; no children were not treated, and none received only radiation therapy. Seven underwent one operation and no further treatment. Fourteen were operated upon and then irradiated. Eight others received operation, radiation, and a second operation at a later date. The treatment received by patients with tumours in each site is summarised in Table IV. The largest proportion of second operations were for thoracic tumour. Of the seven children who did not receive radiation, four had conus/cauda equina tumours and are still alive; one had a cervical glioblastoma multiforme and died 1 month from diagnosis.

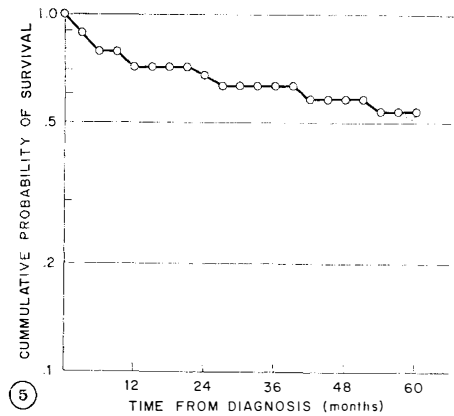
Survival

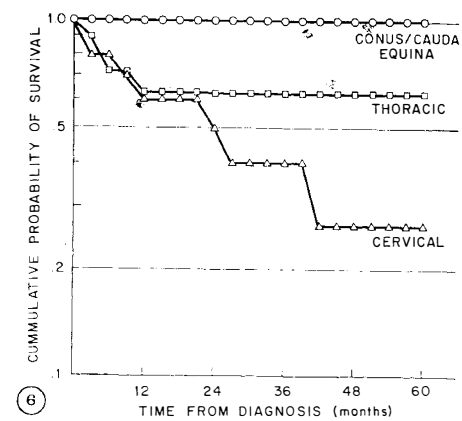
The average survival for the entire series was 61 months; the median survival was 33 months. Figure 5 shows the cumulative probability of surviving at each

TABLE IV

Neoplasms of the spinal cord

Treatment	Cervical	Thoracic	Conus/cauda equina
Operation	2	1	4
Operation and radiation	5	6	3
Operation, radiation, re-operation	3	4	1





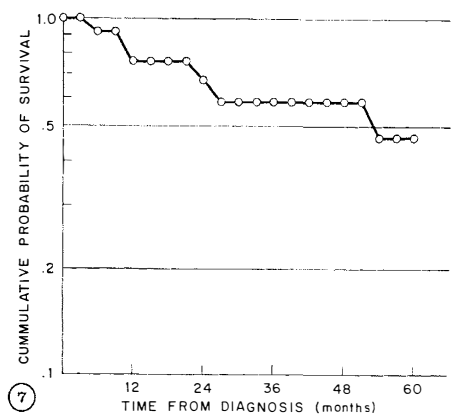


FIG. 5

Survival of children with intraspinal neoplasms. Probability of surviving 1 year was 0·72.

FIG. 6

Survival by location. Survival was shortest with neoplasms of the cervical spinal cord and longest with those of the conus/cauda equina.

FIG. 7

Survival with astrocytoma of the spinal cord. Average survival was 54 months.

3-month interval from diagnosis. At 1 year the probability of surviving was 0·72; from then it declined less rapidly, and at 5 years was 0·54. Six of the 12 deaths took place in the first year. Eleven children have survived longer than 5 years, five longer than 10 years, and one has lived 19 years.

In Figure 6 it can be seen that survival varied considerably with the site of the tumour. With tumours of the cervical spinal cord, the probability of surviving 5 years was only 0·27. Of these ten children, nine have died. The one survivor has lived 33 months. In tumours of the thoracic spinal cord, 5-year probability of survival was 0·62. Six of these 11 children are alive. Only one death has occurred among the eight children with conus/cauda equina tumours. The longest survivor is alive 17 years from diagnosis. Table V shows the average survival with each treatment for tumours in each region.

Common Histopathological Types

Astrocytomas. Astrocytomas, the most common primary intraspinal tumours, presented interesting features as a group. The average age at diagnosis, 11·5 years, was similar to the average of the series as a whole, but ten of the 13 astrocytomas were in children older than ten. Though their presenting symptoms and signs were not unusual, the children with astrocytomas were distinguished as a group by their long history of complaints before a diagnosis was made. Though

TABLE V

Survival: Neoplasms of the spinal cord

	Average survival, months		
	Cervical	Thoracic	Conus/cauda equina
Overall	29	84	77
Treatment			
Operation	13	31	125
Operation and radiation	37	59	17
Operation, radiation, re-operation	25	134	65

astrocytomas are generally slowly-growing, well differentiated tumours, survival varied greatly with location. Of the six children with cervical astrocytomas, five have died. Two of these received chemotherapy in addition to operation and radiation. The average survival with cervical astrocytoma was 25 months. With thoracic astrocytoma, average survival was 92 months, three of five children being still alive. Both children with astrocytoma of the conus/cauda equina are alive, with an average survival of 50 months.

Ependymal neoplasms. The average age of the children with ependymal neoplasms of the spinal cord was 13·3 years (Table I). Five of the seven were girls. Five were located in the conus/cauda equina region, and two were in the thoracic spinal cord. The average survival of these children was 99 months. All but one are still living. The one death occurred in the only child whose tumour was histopathologically classified as an ependymoblastoma, a highly malignant, less differentiated ependymal neoplasm.

Discussion

Histopathological Distribution

The histopathological types of intraspinal neoplasms differ from intracranial neoplasms in Connecticut children over a comparable time period. Gliomas account for 90 per cent of the intraspinal tumours but only 56 per cent of those tumours occurring intracranially (Farwell & Dohrmann, 1976). However, it is striking to note that the percentage of each type of glioma in children is quite similar in both intraspinal and intracranial locations (Table VI).

Intracranial gliomas in adults have a different histopathological distribution than those in children (Dohrmann & Farwell, 1976); however, the percentages of intraspinal gliomas in adults and children are similar as noted in the series of Slooff *et al.*(1964).

In Table VII the spinal cord gliomas of the present series are compared with other large series of intraspinal gliomas in children. From an analysis of the data of the collected series (Rand & Rand, 1960; Slooff *et al.*, 1964; Matson, 1969; Grote *et al.*, 1975; Farwell & Dohrmann, 1976), it was noted that half of all gliomas of the spinal cord in children are astrocytomas and over one-third are of ependymal origin.

TABLE VI

Gliomas of the central nervous system in children

	Brain (%)	Spinal cord (%)
Astrocytoma	54	50
Ependymal neoplasm	18	27
Glioblastoma multiforme	16	11
Spongioblastoma	6	4
Oligodendroglioma	2	0
Glioma	4	8

From Farwell and Dohrmann, *Pediat. Res.*, 1976; and Dohrmann and Farwell, *Dis. Nerv. Syst.*, 1976.

TABLE VII

Five series of spinal cord gliomas in children consisting of 20 or more cases each. The most frequently noted tumours were the astrocytomas followed by ependymal neoplasms. (Number of patients in each group is in parentheses)

	Total no. patients	Astrocytoma*	Ependymal neoplasm	Glioblastoma multiforme	Oligo-dendroglioma	Glioma
Rand and Rand (1960)	20	45% (9)	40% (8)	5% (1)	—	10% (2)
Slooff *et al.* (1964)	32	28% (9)	56% (18)	13% (4)	3% (1)	—
Matson (1969)	30	80% (24)	20% (6)	—	—	—
Grote *et al.* (1975)	21	38% (8)	48% (10)	—	—	14% (3)
Farwell and Dohrmann (1976)	26	54% (14)	27% (7)	11% (3)	—	8% (2)
Total	129	50% (64)	38% (49)	6% (8)	1% (1)	5% (7)

* Includes spongioblastoma.

Location

The ratio of intracranial to intraspinal location for primary central nervous system tumours in children in Connecticut from 1936 to 1975 is approximately 20 : 1 (Farwell & Dohrmann, 1976). As noted in the introduction, this ratio among adults is much less. The present series of tumours (distributed 34 per cent in the cervical region, 38 per cent in the thoracic region, and 28 per cent in the lumbosacral region) does not bear out the rule stated by Slooff *et al.* (1964) that spinal cord tumours are distributed evenly throughout the spinal cord, thereby half occurring in the thoracic spinal cord because that region occupies half the total length of the spinal cord, and one-quarter occurring in each of the cervical and

lumbosacral regions. Matson (1969) found 28 per cent, 41 per cent, and 31 per cent of his series of tumours in the cervical, thoracic, and lumbosacral region respectively.

Age

The pattern of increasing frequency of intraspinal neoplasm with increasing age, seen in the present series, is in contrast to the situation occurring in intracranial tumours (Matson, 1969; Farwell & Dohrmann, 1976). Intraspinal tumours are diagnosed more often in each successive 5-year period up to age 20. Intracranial tumours, however, are most frequently found in the first 5 years of life, and are found less frequently in each successive hemidecade of life. This may be in part due to the predominance of slowly-growing tumours (*i.e.* astrocytomas and ependymomas) in the spinal cord and to the long delay between onset of symptoms and diagnosis which was often a circumstance of these cases. It is of interest that the dermoid was diagnosed in an infant, a case similar to that of Bucy and Buchanan (1935), but the chordoma was in a child of 11 years. Both tumours arise in abnormal cell rests, and are necessarily of antenatal origin, but one did not present until the second decade of life.

Symptoms and Physical Findings

Two-thirds of the children complained of pain, either in the back or neck or in an extremity. This was usually the first symptom, but by the time of diagnosis was almost always accompanied by another complaint. The fact that pain is often the most prominent symptom of spinal cord neoplasms has been mentioned by Foerster and Bailey (1936), Austin (1960) and Slooff *et al.* (1964). This spinal pain is probably related to involvement of, or traction on, dorsal nerve roots, nerves of the pia mater, the dorsal columns or, less likely, the spinothalamic tracts (Austin, 1960). The prominence of the pain at night has been attributed to lengthening of the spinal column in the horizontal position and/or the engorgement of epidural veins in the horizontal position, both of which could result in traction on nerve roots with resulting pain (Eaton, 1941).

There is a long duration of symptoms before diagnosis, and the treatment of symptoms too frequently has involved orthopaedic or urological procedures before a spinal tumour is suspected. Before the advent of polio vaccine, polio was a common admitting diagnosis of these children, as it was for four of Ingraham's 16 cases (1938). Haslam (1975) reported two cases of children with diagnoses of cerebral palsy but with progressive symptoms, who both had tumours of the cervical spinal cord.

Impaired motor function was the most frequent physical finding. Paralysis was not common; however, approximately half of the patients in the series were paretic. Three children were paraplegic before diagnosis. Two were infants who were noted suddenly to be unable to move their lower extremities; earlier signs of weakness might have gone unnoticed. The third was an 11-year-old girl who was paraplegic and progressed to quadriplegia before a cervical astrocytoma was diagnosed.

Involvement of the descending motor system by the tumour would lead to hyperreflexia while that involving lower motor neurons would be associated with diminished or absent deep tendon reflexes.

Papilloedema has been described in certain patients with spinal cord neoplasms. The reasons for this are unclear. Theories offered to explain this include

the postulations that the elevated cerebrospinal fluid (CSF) protein may cause decreased resorption of the CSF, leading to increased intracranial pressure and that blockage of the spinal subarachnoid space may hinder the 'decompressive' action of the lumbar sac thereby causing increased intracranial pressure (Slooff *et al.*, 1964; Ammerman & Smith, 1975).

In some cases the absence of objective findings in the presence of increasing disability leads to a diagnosis of psychiatric disorder (Epstein *et al.*, 1971). As objective findings become manifest then the diagnosis of spinal cord neoplasm is made.

Survival

It is clear from Figure 6 and Table V that location is a prime determinant of survival, tumours of the cervical spinal cord having the poorest prognosis and those of the conus/cauda equina the best. The reasons for this are readily apparent. The tumour may cause weakness compromising respiratory function; extensive resection is much less feasible at higher levels of the spinal cord; and the survival of a patient with a cervical tumour may be shortened by the various complications of quadriplegia. However, the degree of malignancy of the tumour is a factor also. The average survival of the patients with glioblastoma multiforme, a highly malignant astrocytic tumour, was only 3 months although two were thoracic and one was cervical. The average survival of the patients with astrocytoma, a less invasive, better differentiated astrocytic tumour, was 54 months although nearly half were in the cervical region (Figure 7). Similarly, the only death among the children with ependymal neoplasms occurred in the one child whose tumour was an ependymoblastoma; those with ependymomas are all still alive.

The average survival of patients in this series is difficult to compare with those of other authors as various series define 'intraspinal neoplasm' in different ways (from intramedullary tumours only to including primary and secondary neoplasms in the series). In Matson's (1969) series of intraspinal neoplasms in children, 73 per cent survived 1 year, nearly identical to the 71 per cent in the present series. The average survival of the children with intraspinal gliomas in the series of Anderson and Carson (1953) was 54 months, compared to 61 months in the present series.

Summary

Primary intraspinal neoplasms occurring in children in Connecticut over a 40-year period (1936-75) have been reviewed. Twenty-nine such tumours were found. Most of the neoplasms were gliomas: 45 per cent astrocytoma, 24 per cent ependymal neoplasm, 10 per cent glioblastoma multiforme and 7 per cent glioma. The male to female ratio was 1 : 1 and the mean age at diagnosis was 11·3 years. The largest number of neoplasms, 38 per cent, were located in the thoracic spinal cord while 34 per cent and 28 per cent occurred above and below respectively. Length of survival was related to the position of the neoplasm with the probability of survival at 5 years being 0·27 in the cervical region as compared to 1·00 in those of the conus/cauda equina. All children in the series were operated upon and some received radiation therapy and/or chemotherapy. Presenting symptoms and physical findings were reviewed. The data in this population-based study of intraspinal neoplasms in children were compared to other published series and similarities and differences were discussed.

RÉSUMÉ

On a passé en revue les tumeurs primaires intrarachidiennes constatées chez des enfants du Connecticut pendant une période de quarante années de 1936 à 1975. On a constaté vingt-neuf tumeurs pareilles. La plupart des tumeurs s'avérèrent des gliomes: 45 pour cent astrocytomes, 47 pour cent des tumeurs ependymaires, 10 pour cent des glioblastomes multiformes, et finalement 7 pour cent 'gliomes'. Le rapport proportionnel entre les deuz sexes fut égal (1 : 1), et l'age moyen au moment du diagnose fut 11,3 ans. Le nombre le plus élevé des tumeurs, 38 pour cent, se localisa dans la moëlle épinière thoracique, tandis que 34 et 28 pour cent respectivement se trouvèrent en la région cervicale, et dans les régions sacrales et lumbares. La durée de survivance s'avéra par rapport a la situation de la tumeur, la probabilité de survivance après cinq ans étant 0,27 pour cent en la région cervicale, auprès de 1,00 pour cent celles de la *conus/cauda equina*. Tous les enfants de la série furent opérés, tandis que plusieurs entre eux ont subi la thérapie de radiation ou la chémotherapie. On a fait révision des symptomes signalant la présence des tumeurs, et des constatations physiques. Les données de cette enquête à base de population des tumeurs intrarachidiennes chez des enfants ont été comparées à de pareilles enquêtes publiées et leurs distinctions d'avec celle-ci ont été discutées.

ZUSAMMENFASSUNG

Es wurde bei Kindern in Connecticut vorkommende intraspinale Neoplasmen durch einen Zeitlauf von vierzig Jahren, von 1936 bis 1975, überschaut. Neunundzwanzig solcher Geschwülste wurden festgestellt. Die Neoplasmen waren zum grössten Teil Gliome: 45 Prozent Astrozytom, 24 Prozent ependymales Neoplasm, 10 Prozent vielgestaltiges Glioblastom, und schliesslich 7 Prozent 'Gliom'. Das Verhältnis zwischen den Geschlechtern war 1 : 1, und das mittlere Alter zur Zeit der Diagnose war 11,3 Jahre. Die Mehrzahl der Fälle hatten ihre Lage im thorakalischen Rückenmark, wohingegen 34 Prozent und 28 Prozent fanden sich bei der Halswirbelsäule, beziehungsweise beim Lenden- und Sakralmark. Die Überlebens dauer stand in Beziehung zur Lage des Neoplasm; die Wahrscheinlichkeit des Überlebens nach fünf Jahren war 0,27 Prozent, wohingegen 1,00 Prozent bei jenen der *conus/cauda equina*. Jedes Kind wurde operiert, und einige erhielten Strahlungstherapie und/oder Chemotherapie. Die Symptome und physikalische Ermittlungsergebnisse wurden beschrieben. Die Daten dieser auf die Bevölkerung ersetzten Ermittlung der bei Kindern beabachteten intraspinalischen Neoplasmen wurde mit anderen veröffentilichten Reihen verglichen, und Ähnlichkeiten wurden besprochen.

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Discussion to Paper of Dr J. R. Farwell and Dr George Dohrmann

DR TRICOT (*Chairman*). Thank you Dr Farwell. I was personally impressed by the importance of the primary intraspinal neoplasm in children and by the chance of survival. I am sure that we will have questions coming from the floor and I open the discussion now.

DR HUSSEY (*U.S.A.*). Of your survivals, how many were surviving free of disease in contrast to surviving with residual tumour that is still progressing? The reason for asking this is that I have one young lady that I'm following who is now 22, who originally had a thoracic astrocytoma which at the time was known to be incompletely excised, which has slowly grown to the point that she is now a C3 tetraplegic, in contrast to being at onset a T3 paraplegic.

DR FARWELL. The longest survivor among our patients has survived 19 years whereas the latest death among those who died was 23 years after diagnosis. So, especially with astrocytomas in this series a number of children seemed to do well for several years; their symptoms recurred, they'd have another operation and then they'd do well for another couple of years and they would eventually die. I don't have information as to how many, for instance, are bedridden or how many are able to function normally.