Virchows Arch. A Path. Anat. and Histol. 381, 85–96 (1978)

Virchows Archiv A

Involvement of the Larynx in a Congenital "Myopathy", Unilateral Aplasia of the Arytenoid, Micrognathia, and Malformation of the Brain – A New Syndrome?

Horst P. Schmitt

Institute of Neuropathology of the University of Heidelberg (Head: Prof. Dr. G. Ule), Im Neuenheimer Feld 220–221, D-6900 Heidelberg, Federal Republic of Germany

Summary. Neuromyopathic changes were found in various limb muscles and in intrinsic laryngeal muscles of a two month old girl. She had been noted to have micrognathia, arthrogryposis and congenital stridor and died as a result of respiratory insufficiency and aspiration. Autopsy revealed an absent left arytenoid cartilage and severe histogenic abnormalities of the brain. Although the muscles involved showed a mainly myopathic pattern, marked signs of peripheral neurogenic involvement were present. These differed from motor neurone disease or aplasia of anterior horn cells. These findings cast a new light on the discussion of unclassified congenital myopathy resembling the picture of congenital muscular "dystrophy". This is the first case of congenital neuromyopathy in which involvement of intrinsic laryngeal muscles has been demonstrated morphologically.

Key words: Congenital myopathy – Arthrogryphosis – Intrinsic larynx muscles – Aplasia of arytenoid.

Introduction

Neuromuscular disease of the larynx or involvement of the intrinsic laryngeal muscles in primary muscular disorders are poorly represented in oto-rhino-laryngological and neurological literature. Morphological investigations of the intrinsic laryngeal muscles are scanty in traumatic recurrent nerve paralysis in adults (Berendes, 1963; Helmus, 1972) and children (Cavanagh, 1955; Holinger, 1961) despite its important rôle in clinical oto-rhino-laryngology. Myopathic involvement of laryngeal muscles in typhus, pulmonary tuberculosis and trichinosis (Amersbach, 1929) has almost completely dissappeared, and involvement in tetanus and exogenic intoxications are infrequent. Myotonia dystrophica (Curschmann-Steinert) only infrequently affects the larynx (Amersbach, 1929; Piquet and Terracol, 1958), but intrinsic laryngeal muscles are affected more frequently by myasthenia gravis (Berendes, 1963; Hajek, 1932; Luchsinger and

0340-1227/78/0381/0085/$02.40

Arnold, 1970; Piquet et al., 1958). Myositis of the laryngeal musculature is usually said to be secondary to acute or chronic laryngitis (Beckmann, 1963; Berendes, 1963). Involvement of the intrinsic laryngeal muscles has occasionally been reported in oculopharyngeal progressive muscular dystrophy (Maningand et al., 1969; Marter et al., 1969) and in scapuloperoneal muscular atrophy of Stark-Kaeser, where bilateral vocal cord paralysis has occurred (Liversedge and Campbell, 1974; Zellweger and McCormic, 1968).

Congenital laryngeal paralysis with variable clinical patterns of intrinsic laryngeal muscle involvement, preferentially involving the abductors, has only infrequently been analysed by electromyography (Cox and Simmons, 1974). There are no reports of morphological studies or autopsy examination of such cases. Cohen (1973) described eleven operatively treated cases of bilateral abductor paralysis which was due to injury of the recurrent nerve in four of them. In one case paralysis occurred in association with congenital laryngeal stenosis and dislocation and ankylosis of one arytenoid. In two siblings bilateral abductor paralysis had occurred in association with unclassified familial arthrogryposis. In the remaining four cases and unknown neurological cause was implicated. One case exhibited mental retardation as a sign of cerebral demage.

In the case of Cox et al. (1974) bilateral immobility of the vocal cords was due to sclerotic transformation of the interarytenoid muscle, with fixation and partial ankylosis of the arytenoids, while the other intrinsic muscles were intact on electromyography.

The boy was also reported to have a mild "non-progressive spinal muscular atrophy" (neurogenic form of arthrogryposis multiplex?) which was not detailed further.

Among approximately 250 children from the Childrens Hospital of Los Angeles seen between the years 1957 to 1971 (Cohen, 1973) with the clinical diagnosis of bilateral laryngeal paralysis, some had simultaneous "severe central nervous system disease, meningomyelocele with or without hydrocephalus and with or without Arnold-Chiari malformation, and neuromusclus diseases" (see also Cavanagh, 1955; Helmus, 1972; Swischuk et al., 1974; Work, 1941). However, no detailed information about the incidence of the causes and the nature of the muscular changes were given. In all of the eleven cases, treated by unilateral arytenoidectomy, the main initial symptoms were episodes of respiratory distress with stridor and cyanosis, which became worse with feeding, crying or physical stress. The same was true for the cases reported by Priest et al. (1960), Holinger (1961) and Cox et al. (1974).

In the present paper a case of congenital "myopathy" with involvement of the intrinsic laryngeal muscles, arthrogryposis multiplex, micrognathia, and cerebral malformations is described. It is the first autopsy case with investigation of the larynx.

Case Report

S.H., who died at 56 days, was the mature product of a full-term uncomplicated pregnancy and delivery. Two siblings were normal. At birth (March 8, 1977) an abnormally large quantity of

amniotic fluid pointed to hydramnios. The body weight was below normal (2300 g) with a body length of 48 cm. Her mother was 30 years of age and reported that she had not been ill during pregnancy, nor had she undergone x-ray examinations or received any medication. The child's father (34 years old) was said to be healthy. The child showed at birth micrognathia, club-feet, flexion contractures of the hands ("club-hands") as well as of the third finger of the right hand, involving the middle joint. The palate was intact but highly arched, and there was a tendency to glossoptosis, first leading to the clinical diagnosis fo the Pierre-Robin syndrome. There was a marked inspiratory stridor, respiratory distress and enhanced mucus secretion. Intermittent intubation was necessary with repeated aspiration and signs of developing pneumonia, and severe attacks of bradycardia during sucking off mucus. The result of direct laryngoscopy was said to be normal, although clinically a tracheomalcia had been diagnosed. During one of the severe attacks of dyspnea and aspiration the infant suddenly died. Chromosomal analysis, performed in the Laboratory of Cytology and Genetics of the Department of Pediatrics of the Heidelberg University (Dr. Kratzer, M.D.) revealed a normal karyotype (46 XX) without gross chomosomal aberrations.

Results

General autopsy (A-Nr. 460/77, Inst. of General Pathology, Heidelberg) disclosed an aspiration pneumonia and signs of myocardial hypoxia. No visceral malformations were found.

Neuropathological Findings. Brain and spinal cord: The brain weight was below normal (310 g; normally about 450 g according to Lemire et al., 1975). There was a partial persitence of the primary sulci ("Affenfurchen") and severe micropolygyria involving almost all parts of the forebrain, less marked in the temporal lobes and at the base (Fig. 1a). Neuronal heterotopias were few. Hypoplasia of the corpus callosum and the septum pellucidum was related to an abnormal enlargement of the foramina of Monro resembling the picture of single ventricle with hydrocephalic widening of the telencephalic ventricular lumen. Both pyramids in the medulla oblongata appeared hypoplastic, the arcuate nuclei, however, being present. Microscopical examination did not reveal any definite neuronal deficit or *primary* pathological changes in neurons in the motor nuclei of the vagus nerve nor in the anterior horns of the spinal cord. In the cervical enlargement and the lumbosacral parts of the cord some motor neurons showed the typical picture of secondary or retrograde swelling with central chomatalysis and excentrically displaced nucleus, characteristic of peripheral axonal damage (Fig. 1b–f).

Voluntary Muscles. The intrinsic laryngeal muscles (m. vocalis, thyreoarytenoideus, cricothyreoideus, mm. cricoarytenoidei posteriores) showed severe sclerotic changes microscopically, with rounding and marked atrophy of the remaining muscle fibres, mainly on the left (Fig. 2a–d). In the severely atrophic fibres distinct cross striation was often preserved. In the right posterior cricoarytenoid muscle, areas with myopathic changes were combined with small focal areas of marked atrophy; often only residual sarcolemmal nuclei were seen. Central nuclei were scarce and there were no typical myotubes, neither in the intrinsic nor in the extrinsic laryngeal muscles. Minimal sclerotic lesions were found in the left omohyoid muscle.

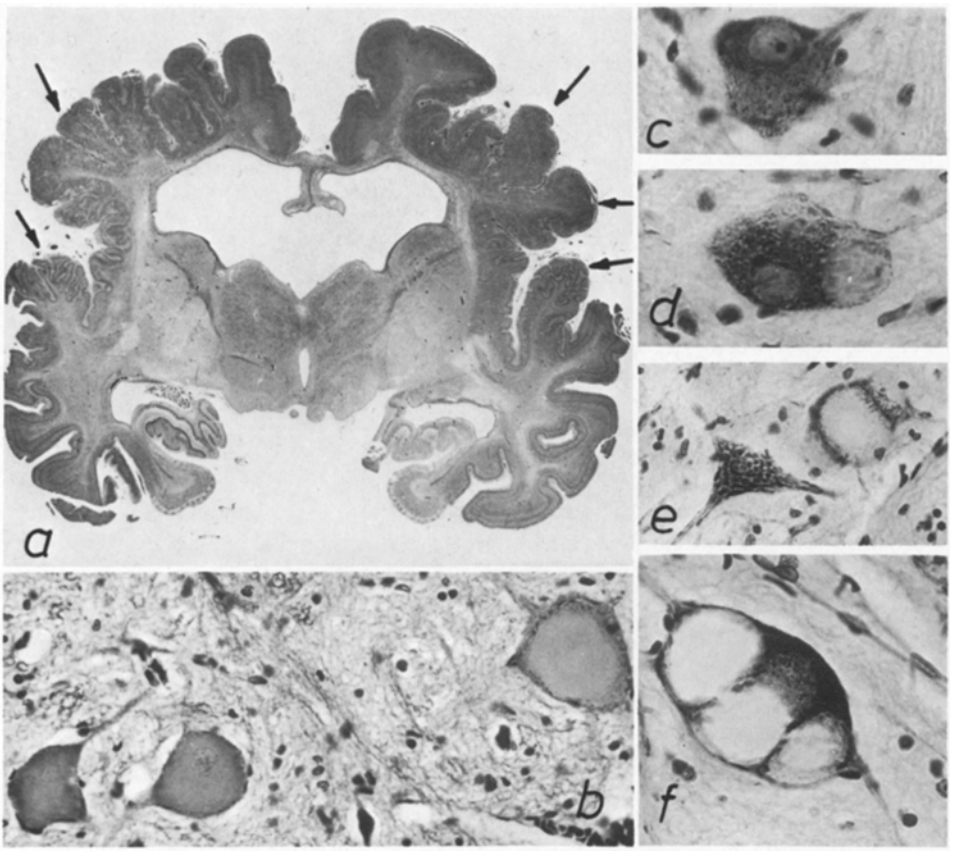

Fig. 1a–f. Changes in the central nervous system: **a** Extensive micropolygyria with the typical tubular pattern of the cortex (→); **b** central chromatolysis of anterior horn neurons in the cervical spinal cord indicating distant axonal damage (Nissl, orig. ×250); **c–f** central chromatolysis changing to vacuolar degeneration in the anterior horns of the lumbosacral spinal cord (Nissl, orig. ×400)

Voluntary muscles from different body regions (m. erector trunci, m. deltoideus, m. brachioradialis, m. gluteus maximus, and m. tibialis anterior) displayed similar and usually moderate "myopathic" changes with focal areas of muscle atrophy and sclerotic or fatty replacement. In the gluteus maximus the presence of small foci of intrafascicular fat without signs of acute degenerative changes of the bordering muscle fibres suggested benign non-progressive myopathy with focal liposclerosis of the muscle (Fig. 3e). Similar findings were observed in the other muscles. The anterior tibial muscle (Fig. 3a–c) alone displayed focal areas with progressive myopathic change including moderate vacuolar degeneration of muscle fibres without phagocytosis, but with infrequent regenerative phenomena. These areas were combined with areas of small-group atrophy where persisting sarcolemmal nuclei were often the only remaining feature. Small intramuscular nerve branches often showed loss of myelin sheaths and axonal changes, the same being true for small nerve twigs in the affected

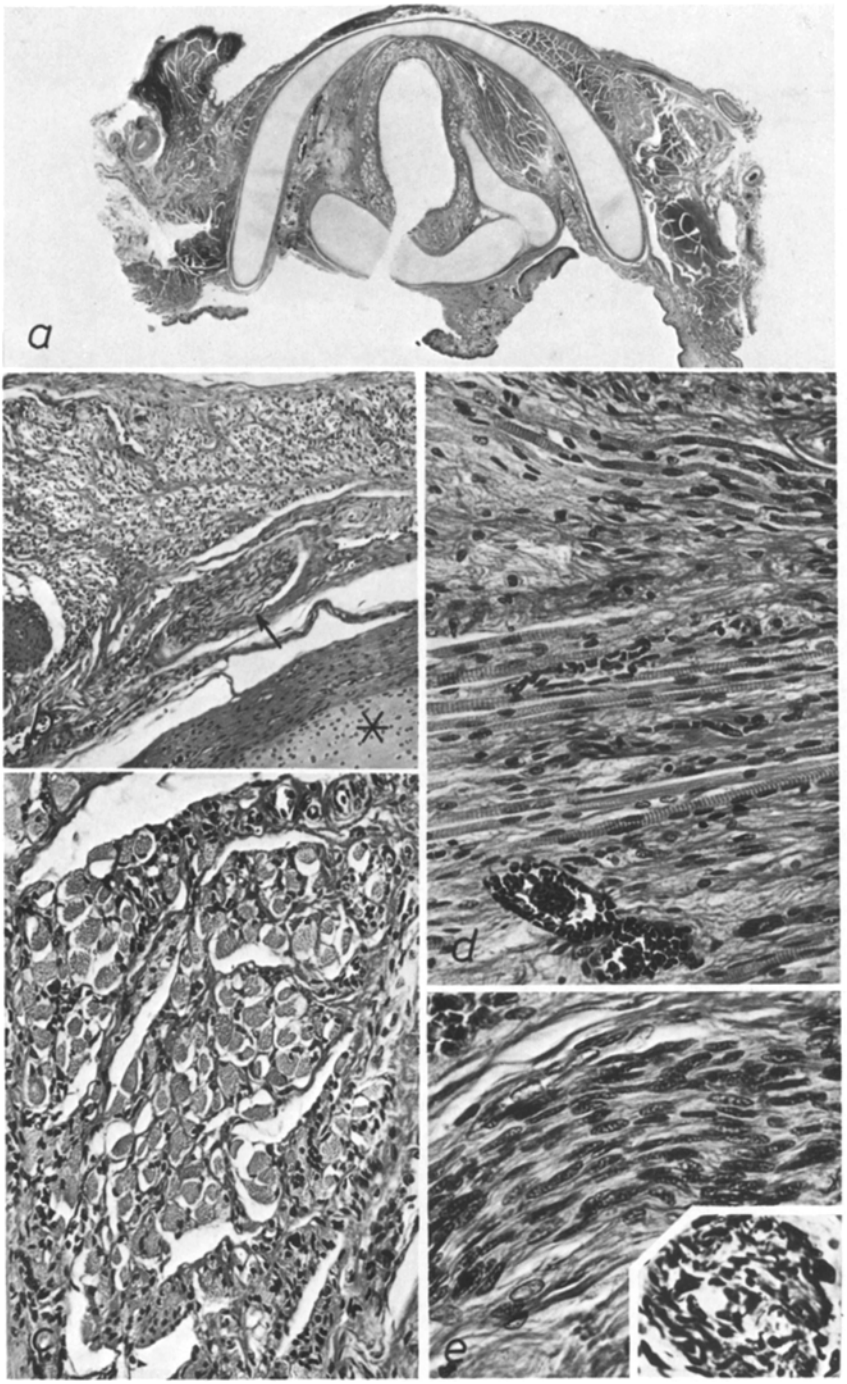

Fig. 2a–e. Changes of the larynx: **a** Total cross section on the level of the vocal cords, showing the absence of the left arytenoid and fibrotic change of the left cord muscles and the posterior cricoarytenoid muscles; **b** posterior cricoarytenoid muscle on the left showing severe atrophy of the muscle fibres and pronounced fibrosis; (→) twig of the left recurrent nerve exhibiting an increase in Schwann cell nuclei (*cricoid cartilage; Masson-Goldner, orig. ×100); **c** right cricoarytenoideus posterior displaying myopathic fibre changes with rounding of fibre cross sections and fibrosis, combined with scattered small groups of markedly atrophic fibres (Masson-Goldner, orig. ×250); **d** left thyroarytenoid muscle showing subtotal sclerotic change, the remaining muscle fibres still exhibiting a distinct cross striation (Masson-Goldner, orig. ×250); **e** another twig of the left recurrent nerve with loss of myelin sheaths and increase in Schwann cell nuclei (Masson-Goldner, orig. ×400); inset: axonal deficits (Bodian; ×400)

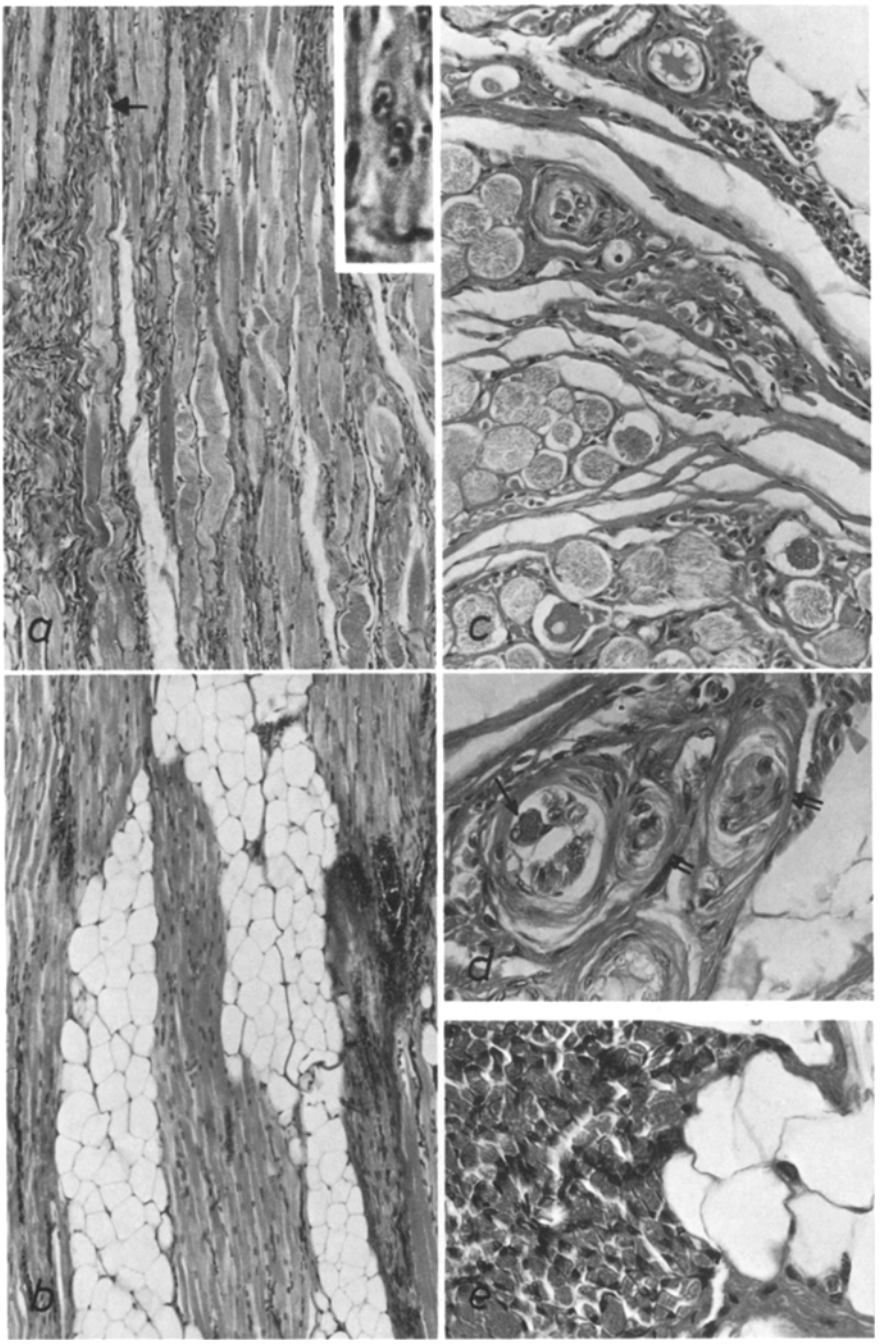

Fig. 3 a–e. Changes in muscles of the lower limbs (a–d anterior tibial muscle, e gluteus maximus): **a** area with progressive myopathic changes of muscle fibres including hyalin degeneration, loss of cross striation with granular degeneration, regeneration (→) and marked fibrosis (Masson-Goldner, orig. ×100); inset: high power view of the arrowed multinucleated "myoblast"; **b** area with non-progressing liposclerotic changes (orig. ×100); **c** myopathic changes including vacuolar degeneration, grouped fibre atrophy and sclerosis (orig. ×250); **d** partially degenerated intramuscular nerve twigs (⇉) and muscle spindle (→); **e** non-progressing liposclerotic change in the gluteus maximus (Masson-Goldner, orig. ×100)

intrinsic laryngeal muscles (Fig. 2e, 3d). In areas with progressing myopathic affection the musculature was replaced by dense connective tissue, while in other areas in the anterior tibial muscle fatty replacement without signs of progression was seen, as found in the other muscles (Fig. 3a, b).

In the larynx the left arytenoid cartilage was found to be absent (Fig. 2a).

Comments

Sclerosis of several intrinsic laryngeal muscles and aplasia of the left arytenoid cartilage have been demonstrated by autopsy examination in a two month old female infant suffering from respiratory distress, severe inspiratory stridor and aspiration. The muscular changes were mainly consistent with the unclassified type of benign non-progressive congenital myopathy (? dystrophy, see Adams, 1975, p. 245). Similar changes were present in other voluntary muscles. The patient had arthrogryposis. The anterior tibial muscle primarily showed myopathic changes. However, small-group atrophy, which is considered to be a sign of neurogenic involvement, was also present, and intramuscular nerve twigs showed loss of axons and myelin sheaths.

Associated brain malformations consisted of micropolygyria and compensated hydrocephalus, indicating disturbances of the histogenetic differentiation of the brain, e.g. factors acting during the second half of pregnancy. Since complications during gestation and perinatal asphyxia could be ruled out, the changes must be regarded as primary malformations, the association with micrognathia and highly arched palate *perhaps* pointing towards an impairment of the neck-head "organizer" of Spemann or the induction of neck and head development, respectively. Disturbances of Spemann's organizer may occur either in isolated instances owing to exogenous factors or may be due to genetic mechanisms. Although a chromosomal aberration was excluded, and despite two normal siblings, a genetic determination of the malformation cannot be ruled out in the present case. The child might have been the first homozygous individual in the family with both parents heterozygous for the gene. A definite decision cannot be made on the basis of the present data.

An especially important question is whether the neuromyopathic changes of the intrinsic laryngeal and other voluntary muscles were due to the brain malformation and thus of neurogenic origin, or whether the muscular changes and the malformation of the brain were both due to a genetic cause. This is a problem of general significance in the interpretation of certain froms of congenital myopathy (? dystrophy), which often seem to be accompanied by clinical signs of cerebral damage ("mental retardation", see Segawa, 1970, 1971). Unfortunately, the pathoanatomical causes of the cerebral impairment in most of these cases have not been established by clinical means or by autopsy.

In case of a direct dependence of the neuromyopathic changes to the cerbral lesions the condition may be termed "cerebral muscular atrophy" according to von Meyenburg (1929). Cerebral muscular atrophy might be defined as *congenital or acquired muscular atrophy associated with cerebral damage, the muscular changes not exhibiting the typical pattern of motor neurone disease* in the usual

sense, e.g. large-group atrophy. A typical example in adult life is the muscular atrophy on the *ipsilateral* side of a thalamic glioma or in association with other focal damage of the brain, as will be demonstrated in another paper.

In general terms, the muscular changes in congenital brain damage might be the result of disproportionate innervation of antagonistic muscles or of parts of the same muscle due to inadequate number or intensity of central nervous impulses, leading to trophic impairment of the related muscle fibres and nerve endings. To date, there is insufficient knowledge about these conditions for a detailed hypothesis on the possible relation between cerebral damage and muscular atrophy to be constructed.

In the present case, a gross loss of neurons or signs of acute primary neuronal damage could be demonstrated neither in the anterior horns of the spinal cord nor in the nucleus ambiguous (see Szentágothai, 1943). The motor cortex does not yet play an important functional rôle in muscular innervation in early infancy.

Some motor neurons of the cervical enlargement and the lumbosacral parts of the spinal cord showed central chromatolysis, e.g. "acute retrograde changes" (Bielschowsky) usually regarded as typical signs of peripheral axonal damage. In the lumbosacral region chromatolytic neurons also displayed vacuolar degeneration. According to Becker (1953) and Jacob (1957) central chromatolysis and vacuolar degeneration may also occur with anterograde transneuronal degeneration, which should be considered in principle in the present case because of the forebrain malformation. However, in the adult case with "cerebral muscular atrophy" due to thalamic glioma mentioned above, single centrally chromatolytic neurons were also found together with marked signs of distal neuropathy of the intramuscular nerve branches. Their features suggested a neuropathy of the dying-back type. In this case the marked extent of the muscular lesions did not correspond with the infrequent appearance of central chromatolysis in motor neurons of the spinal cord. Hence the muscle damage could not be regarded as the result of an anterograde transneuronal degeneration due to a lesion of the pyramidal tract. In addition, muscular changes should not have occurred on the ipsilateral side of the glioma.

In the present case, the pattern of muscular changes did not correspond to the picture of spinal muscular atrophy expected in anterograde transneuronal degeneration. On the contrary, small-group atrophy and degeneration of intramuscular nerve twigs pointed to an involvement of peripheral neurogenic mechanisms at least in some areas, central chromatolysis being due to distal axonal damage.

In 36 biopsied cases out of 78 clinically examined cases of autosomal recessively inherited congenital muscular "dystrophy" with mental retardation, Segawa (1970, 1971) found a reduction in size of the intramuscular myelinated nerve fibres below 6 μm in diameter and "remarkable" deformities of endplates". The causes of mental retardation were not further analysed. In these cases and in the present one the muscular changes were chiefly myopathic. Only in the anterior tibial muscle of our case were some areas of small-group atrophy clearly indicative of distal neurogenic disturbances.

Marked myopathic involvement in peripheral neurogenic atrophy is well documented in the diverse forms of peroneal muscular atrophy (Charcot-Marie-Tooth). Goebel (1977) demonstrated that the angular deformity of the cross sectional shape of muscle fibres considered to be indicative of neurogenic atrophy in adult life is absent during early infancy, where the muscle fibres are rounded, as in primary myopathy. Hence, even in the areas suggestive of myopathy in the present case an involvement of a neurogenic mechanism cannot be excluded. However, the big *extramuscular* portions of the nerves examined (sciatic, tibial and deep peroneal nerve) had all been grossly intact.

Acute fibre necrosis and phagocytosis, probably reliable signs of primary myopathy, were absent here and rare in Segawa's cases of slowly progressive muscular "dystrophy". Regeneration was found to be infrequent.

The clinical features of our case resembled the Pierre-Robin syndrome. The glossoptosis in PR syndrome is responsible for the respiratory distress, which can be very dramatic and require rapid surgical treatment (Assemany et al., 1971; Härle et al., 1970; Robin, 1923; Singh et al., 1970). In the majority of the cases of PR syndrome further malformations including dislocations of the hips were also found (Härle et al., 1970). Cleft palate was only absent in a very few cases. Investigations of the larynx have not been mentioned in the recorded literature, but in most of the cases, abnormalities of the larynx are unlikely since respiratory distress can usually be relieved by operation on the tongue (Härle et al., 1970). In the present case absence of cleft palate was inconsistent with the PR syndrome. In addition, as far we as we know, brain malformations have not been reported in the latter.

Changes in the intrinsic laryngeal muscles in arthrogryposis have been reported very infrequently (Cohen, 1973; Cox et al., 1974). The nature of the muscular changes has not been analysed by morphological methods and only once been examined by EMG. In the cases in Table 1 the pattern of muscular involvement of the larynx differed significantly from that in the present case, as far as can be judged from the clinical data.

As far as we know, aplasia of one or both arytenoids has not been reported in the literature.

Despite the lack of morphological confirmation the cases in Table 1, and the present observation, indicate that involvement of intrinsic laryngeal muscles in congenital myopathy (neuromyopathy) should be considered more often, especially in cases with congenital stridor, PR syndrome-like clinical picture, and before making the unsatisfactory diagnosis of tracheomalacia.

As far as we can see from the literature, vocal cord paralysis is usually ascribed to recurrent nerve paralysis on the basis of direct laryngoscopy without further confirmation of the diagnosis by EMG of the laryngeal muscles or other methods. However, this observation and that of Cox et al. (1974) demonstrate that vocal cord paralysis can also occur with congenital neuromyopathy with involvement of distal neurogenic mechanisms, which are not identical with a recurrent nerve lesion. Perhaps at least some of the recorded cases of vocal cord paralysis of unknown cause (Cavanagh et al., 1955; Cohen, 1973, Faarborg-Andersen, 1954) may be identified as congenital neuromyopathy restricted to

Table 1. Congenital (non-acquired) neuromyopathy of the intrinsic laryngeal muscles

Author year	Case-nr. Sex/age	Basic disorder(s)	Diagnosis (Laryng.)	EMG	Method	Morpholog. findings	Mental disturbances
Cavanagh (1955)	1) 3 cases 2) 8 cases < 1 yr	MMC + AChM + Hy unknown causes	UAbP + BAbP	O	L	O	not mentioned
Priest et al. (1960)	3) f 10 mo	unknown cause (congen. heart dis., patent d.a.)	BAbP	O	L	O	none
Holinger (1961)	32 cases	MMC 4 cases mongolism 1 case Hy 1 case m.c.a. 2 cases c.h.d. 9 cases unknown 15 cases	BAbP + UAbP	O	L	O	mental retard. in 3 cases
Zellweger et al. (1968)	1) m 4 yrs	SPA	BVCP	O	L	O	none
Cohen (1973)	1) f < 1 yr	"arthrogryposis"	BAbP	O	L + AE	O	none
	2) f 13 mo[b]	"arthrogryposis"	BAbP	O	L + AE	O	none
	3) m < 1 yr	unknown cause	BAbP	O	L + AE	O	suspected (??)
	4) m 13 mo	unknown cause	BMP	O	L + AE	O	none
	5) m 12 yrs	unknown cause	BAbP	O	L + AE	O	none
	8) m 2 yrs	c.h.d. + p.d.a.	BAbP	O	L + AE	O	none
	10) f 3 weeks	combined malform. syndrome: glottic webb, subglottic stenosis, disloc. of one arytenoid	BMP	0	L + AE	O	none
Cox et al. (1974)	1) m 5 yrs	"non-progressive benign infantile spinal musc. atroph." (mild hypospadius)	interarytenoid m. paralysis	+	L + sectioning	fibrosis and atrophy	none
Liversedge et al. (1974)	1) ?	SPA	BVCP	O	?	?	not mentioned

[a] Age on first admission to hospital

[b] 1 and 2 were sisters

AE = arytenoidectomy, AChM = Arnold-Chiari malform., BAbP = bilateral abductor paralysis, BMP = bilateral midline paralysis, BVCP = bilateral vocal cord paralysis, c.h.d. = congenital heart disease, Hy = hydrocephalus, f = female, L = laryngoscopy, m = male, m.c.a. = multiple congenital anomalies, MMC = meningomyelocele, SPA = scapuloperoneal atrophy, UAbP = unilateral abductor paralysis, p.d.a. = patent ductus arteriosus

the larynx, if this possibility were taken into consideration. Clinically, a clear differentiation can only be achieved through a laryngeal EMG. If more attention were paid to the larynx, in lethal cases, the association of congenital neuromyopathy, unilateral aplasia of the arytenoid cartilage, micrognathia, and cerebral malformation will perhaps not remain a single observation.

References

Adams, R.D.: Diseases of muscle. A study in pathology. 3rd Ed. Hagerstown, Maryland: Harper & Row 1975

Amersbach, K.: Die Nervenkrankheiten des Kehlkopfes und der Luftröhre. Myopathische Lähmungen. In: Handbuch der Hals-Nasen-Ohrenheilkunde, A. Denker, O. Kahler, eds., Vol. V, pp. 791–929. Berlin: Springer 1929

Assemany, S.R., Kajii, T., Gardner, L.J.: Syndrome of phocomelia with mandibular hypoplasia. Helv. Paediat. Acta **26**, 403–409 (1971)

Beck, K., Schneider, P.: Mißbildungen und Anomalien des Kehlkopfes, der Luftröhre und der großen Bronchien. In: Handbuch der Hals-Nasen-Ohrenheilkunde (A. Denker, O. Kahler, eds.), Vol. II, p. 428. Berlin-München: Springer-Bergmann 1926

Becker, H.: Retrograde und transneuronale Degeneration der Neurone. In: Abhandl. der Akademie der Wissenschaften, mathemat.-naturwissenschaftl. Klasse, No. 10, Mainz: Verlag der Akademie der Wassenschaften 1953

Beckmann, G.: Myositis des Larynx. In: Hals-Nasen-Ohren-Heilkunde (J. Berendes, J. Link, F. Zöllner, eds.), Vol. II, p. 888. Stuttgart: Thieme 1963

Berendes, J.: Krankheiten der Kehlkopfmuskulatur. In: Hals-Nasen-Ohren-Heilkunde (J. Berendes, J. Link, F. Zöllner, eds.), Vol. II, p. 1165. Stuttgart: Thieme 1963

Cavanagh, F.: Vocal cord palsies in children. J. Laryngol. **69**, 399–418 (1955)

Cohen, S.R.: Arytenoidectomy in children. Laryngoscope **83**, 1293–1299 (1973)

Cox, D.J., Simmons, F.B.: Midline vocal cord fixation in the newborn. A new syndrome. Arch. Otolaryngol. (Chic.) **100**, 219 (1974)

Faarborg-Andersen, K.: Recurrent laryngeal paralysis of unknown aetiology. Acta oto-laryng. Supp. **118**, 68–75 (1954)

Goebel, H.-H., Muller, J.: The unusual features of traumatic neurogenic muscular atrophy in the infant: An anatomic study. Neuropädiatrie **8**, 274–285 (1977)

Härle, F., Lengsfeld, C., Vahlenkamp, H.: Pierre-Robin-Syndrom. Mschr. Kinderheilk. **118**, 611–624 (1970)

Hajek, M.: Myopathische Lähmungen. In: Pathologie und Therapie der Erkrankungen des Kehlkopfes, der Luftröhre und der Bronchien, p. 469. Leipzig: Curt Kabitzsch 1932

Heatly, C.A.: Larynx in infancy; study of chronic stridor. Arch. Otolaryngol. (Chic.) **29**, 90–103 (1939)

Helmus, Ch.: Microsurgical thyrotomy and arytenoidectomy for bilateral recurrent laryngeal nerve paralysis. Laryngoscope **82**, 491–503 (1972)

Holinger, P.H.: Clinical aspects of congenital anomalies of the larynx, trachea, bronchia, and esophagus. J. Laryngol. **75**, 1–44 (1961)

Jacob, H.: Sekundäre, retrograde und transsynaptische Degeneration. In: Handbuch der speziellen pathologischen Anatomie und Histologie (O. Lubarsch, F. Henke, R. Rössle, eds.), Vol. XIII/1A, pp. 266–336. Berlin-Göttingen-Heidelberg: Springer 1957

Lemire, R.J., Loeser, J.D., Leech, R.W., Alvord, E.C.: Normal and abnormal development of the human nervous system. New York: Harper & Row 1975

Liversedge, L.A., Campbell, M.J.: Scapuloperoneal atrophy. In: Disorders of voluntary muscle (J.N. Walton, ed.), pp. 782–783. Edinburgh-London-New York: Churchill Livingstone 1974

Luchsinger, R., Arnold, G.E.: Myopathisch bedingte Stimmstörungen (Myasthenia gravis pseudoparalytica). In: Handbuch der Stimm- und Sprachheilkunde, Vol. I, pp. 381–382. Wien-New York: Springer 1970

Manigand, G., Lucso, M., Deparis, M.: Les myopathies oculaires. A propos d'une observation familiale de dystrophie musculaire oculo-pharyngée et squélettique à début tardif. Sem. Hôp. Paris **45**, 2803–2808 (1969)

Marter, J.M., Stoebner, P., Stephan, F., Isch, F.: Myopathie oculaire compliquée tardivement d'une attainte des muscles de la déglutition, de la phonation et de la racine des quatres membres. Rev. oto-neuro-ophthal. **41**, 315–323 (1969)

Meyenburg, H. von: Zerebrale Muskelatrophie. In: Handbuch der speziellen pathologischen Anatomie und Histologie (O. Lubarsch, F. Henke, eds.), Vol. IX/1, p. 424. Berlin: Springer 1929

Piquet, J., Terracol, J.: Le maladies du larynx. Le larynx dans la maladie de Steinert. Paris: Masson & Cie 1958

Priest, R.E., Ulvestad, H.S., Water van de, F., Richardson, R.J.: Arytenoidectomy in children. Ann. Otol. Rhinol. Laryngol. **69**, 869–881 (1960)

Robin, P.: La chute de la base de la langue considérée comme une nouvelle cause de gène dans la respiration nasopharyngienne. Bull. Acad. Méd. (Paris) **89**, 37–42 (1923)

Segawa, M.: Clinical studies of congenital muscular dystrophy. (Arthrogrypotic type congenital muscular dystrophy with mental retardation and facial muscle involvement). Brain Developm. (Tokyo) **2**, 67–79 (1970)

Segawa, M.: Histological, histochemical and electron microscopical studies of biopsied muscle of congenital muscular dystrophy (Arthrogrypotic type congenital muscular dystrophy with mental tetardation and facial muscle involvement). Brain Developm. (Tokyo) **3**, 21–36 (1971)

Singh, R.P., Laco, N.T., Vigna, V.: Pierre-Robin-syndrome in siblings. Am. J. Dis. Child. **120**, 560–561 (1970)

Swischuk, L.E., Smith, P.C., Fagan, C.J.: Abnormalities of the pharynx and larynx in childhood. Seminars Roentgenol. **9**, 283–300 (1974)

Szentagothai, J.: Die Lokalisation der Kehlkopfmuskulatur in den Vaguskernen. Z. Anat. Entwickl.-Gesch. **112**, 704 (1943)

Work, W.P.: Paralysis and paresis of vocal cords; statistical review. Arch. Otolaryngol. (Chic.) **34**, 267–280 (1941)

Zellweger, H., McCormick, W.F.: Scapuloperoneal dystrophy and scapuloperoneal atrophy. Helv. Paediat. Acta **23**, 643–649 (1968)

Received July 6, 1978