

Vertebral resection and fusion for paralytic kyphosis

9 patients followed up for 6 (2-14) years

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Nine patients with a thoracolumbar, progressing, paralytic kyphosis, pressure sores from gibbus, an inability to lie on the back, and deterioration of the sitting balance were operated on with resection of two to three vertebrae and a thoracolumbar fusion. One child died from intracranial bleeding caused by a

halo screw. There were no implant loosening or non-unions. Pressure sores healed, sitting improved, and lying on the back became possible. A mild scoliosis above the fusion level developed in 2 patients, but neither of them needed any treatment.

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A lumbar kyphosis may be present at birth in some children with a thoracolumbar myelomeningocele. There is a total neurologic deficit at the lumbar levels, the associated spina bifida is wide, and the paraspinal muscles do not cover the top of the kyphosis. Sharrard and Drennan (1972) found that the kyphosis could exceed 80° at birth; and at the age of 8 years, the majority of curves were over 170°. A compensatory thoracolumbar lordosis develops above the kyphosis, and this further accentuates the sharp gibbus. Sitting and lying on the back are very difficult, and the child has to support herself/himself with the arms to maintain the sitting balance. The anesthetic and scarred skin over the kyphosis easily develops pressure sores. Respiration may be impaired by the upward pressure of the compressed abdominal contents against the diaphragm.

To prevent these problems, Sharrard (1968) introduced his technique of spinal osteotomy and resection of the kyphosis in the newborn. The deformity, however, tended to recur. Later, Sharrard and Drennan (1972) extended the technique to older children, with more successful results. Other surgeons have used similar techniques, and found this to be a major procedure associated with life-threatening complications (Eckstein and Vora 1972, Hall and Poitras 1977, Leatherman and Dickson 1978, Lowe and Menelaus 1978, Lindseth and Stelzer 1979, Mayfield 1981, Christofersen and Brooks 1985, Heydemann and Gillespie 1987, McMaster 1988). Many of these authors consider a long fusion including the sacrum necessary to prevent a recurrence of the deformity. However, after this procedure, the patients have great

difficulties moving, for instance, from lying to sitting or between chairs of different heights.

Thus, it would be desirable to restrict the fusion area and to spare mobile segments both in the shoulder and in the lumbosacral areas as reported by Lindseth and Stelzer (1979) and Christofersen and Brooks (1985). We report long-term results of this procedure in 9 patients, 7 of whom had myelomeningocele.

Patients and methods

From 1976 to 1988, 9 patients (8 girls and 1 boy) with a severe lumbar paralytic kyphosis were treated at our unit with resection of their kyphosis, spinal instrumentation, and fusion. In 7 cases the diagnosis was myelomeningocele. In all 7 cases the level of the arch defect was thoracic, and varied from Th-8 to Th-11. One patient had sacral agenesis, and vertebral malformation with spina bifida occulta caudally from Th-11. One patient's total lower thoracic paralysis was caused by a neuroblastoma, which was treated surgically—including resection of lower thoracic vertebral arches—and radiation before the age of 1 year.

Two of the patients, who had the level of arch defect at Th-8 and Th-9, had been walkers with orthotics and walking aids up to the age of 4 and 6 years, respectively. They, however, lost their walking function. It is likely that the progress of their kyphosis was the cause of the deterioration of their neurologic function. In the remaining 5 patients, there had been no motor or sensory function at the lumbar levels.

Table 1. Clinical data for 9 children operated by vertebral resection and fusion for paralytic kyphosis

Case	Fusion	Implants	Follow-up (yrs)	Kyphosis in degrees			Sacral inclination backward in degrees			Lumbar scoliosis Cobb's angle			Thoracic scoliosis Cobb's angle		
				A	B	C	A	B	C	A	B	C	A	B	C
1	L1-L4	halo-pelvic	14	54	42	50	* -	-	-	25	0	18	0	0	0
2	Th11-L5	+ plate	-	125	-	-	15	-	-	15	-	-	63	-	-
3	Th12-L2		12	60	43	80	n	n	n	60	54	45	0	0	0
4	Th12-L5	screws	6	140	50	50	90	35	45	20	0	0	41	40	40
5	L2-L5	+ wires	2	123	65	90	24	0	0	20	0	0	63	58	58
6	L2-L5	+ plates	6	120	38	37	45	18	18	20	0	0	0	0	20
7	L2-L5	+ rods	4	140	34	36	90	0	20	40	0	0	0	0	10
8	L1-L5		4	138	70	70	20	20	20	53	0	0	0	0	0
9	L1-L5	+ wires	2	145	60	75	0	n	n	27	0	0	0	0	0

A Preoperative, B Postoperative, C Review.

* Sacral agenesis.

n Normal forward inclination of the sacrum.

All the patients had a very severe, progressive spinal deformity resulting in a loss of sitting balance and necessitating the use of the arms for support. In all the cases, the kyphosis had progressed before the surgery. In 2 cases, the radiographs from the time before the preoperative assessment were no longer accessible, but the information was found in the patients' records. All the patients had problems with pressure sores over the apex of their kyphosis. The range of movement in their hip joints preoperatively was enough to allow sitting postoperatively. Four patients had a unilateral and 1 patient a bilateral hip dislocation. All the patients were under pediatric control for urinary tract problems and for hydrocephalus shunts.

The first orthopedic consultation took place at a mean age of 8 (1-11) years because of increasing problems. The mean age at surgery was 10 (6-16) years. The mean follow-up period was 6 (2-12) years.

The follow-up study included clinical and radiographic examinations. Radiographs with anteroposterior and lateral views were obtained with the patient in the sitting position. The following parameters were assessed: level and extent of the kyphosis and kyphotic angle, the Cobb angle of thoracic and lumbar scoliosis, the position of the sacrum in the sagittal plane, and healing of the fusion.

Operative technique

The patient was placed prone on the operating table on a special cradle that allowed the abdomen to hang free. A midline longitudinal incision was made over the apex of the kyphosis, extending from the lower thoracic region to the lumbosacral region. Any ulcerated area was excised with the skin incision. The skin

and subcutaneous tissues, which were usually thin and adherent to the underlying tissues, were dissected bilaterally to the margins of the laminar defect leaving as thick flaps as possible. The muscles were sharply stripped from the sides of the kyphosis, and the dissection continued to the front of the vertebral bodies. The segmental vessels were ligated, and the nonfunctioning spinal nerves were divided as necessary. The nonfunctioning spinal cord was dissected free from the vertebrae and transected immediately distal to the osteotomy level. The dura was dissected free and sutured.

In spite of this extensive soft-tissue release, the kyphosis remained rigid, and correction could only be obtained by resecting apical vertebrae—one to two whole vertebral bodies and two halves—and shortening the spine. Sufficient bone was removed to allow flattening of the spine and close apposition of the everted bone ends, which were beveled. The correction was maintained by applying posterior compression rods, screws and/or wires. All the exposed bony surfaces were decorticated and grafted with autologous bone. Once the deformity had been corrected, there was usually redundant skin and subcutaneous tissues to provide a soft-tissue pad over the implants and any residual kyphosis (Figure 1).

The level and extent of the vertebral resection and fusion, as well as the implants used, are presented in Table 1. In the first 3 cases, halo-pelvic distraction was used preoperatively to achieve a better correction. Later, however, it was obvious that the technique of the vertebral resection and instrumentation was of more importance than the troublesome—and in 1 case fatal—preoperative halo-pelvic distraction.

After 1 to 2 weeks' bed rest, a total-contact, polyethylene body jacket was applied, and the patient was allowed to sit for short periods. The patient was also

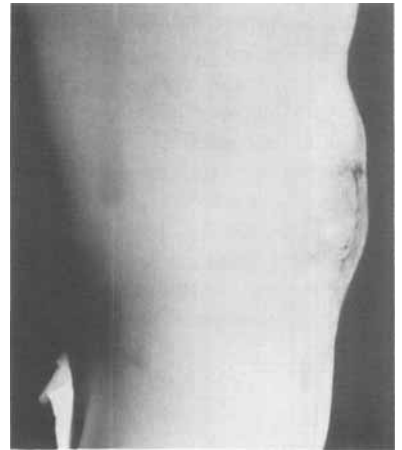
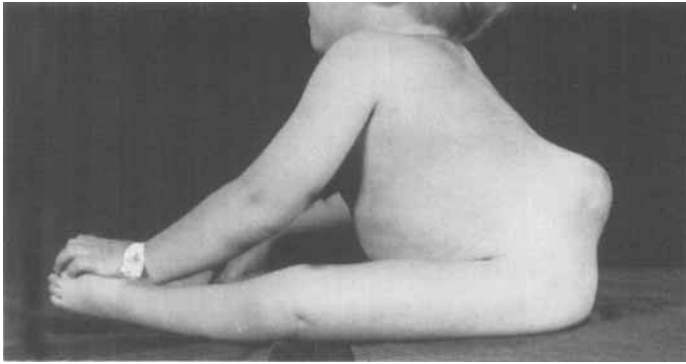
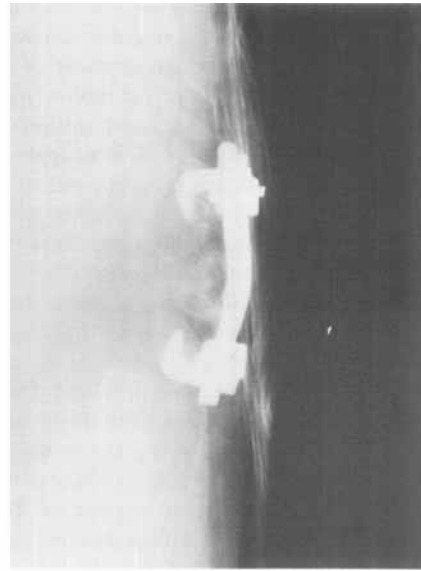
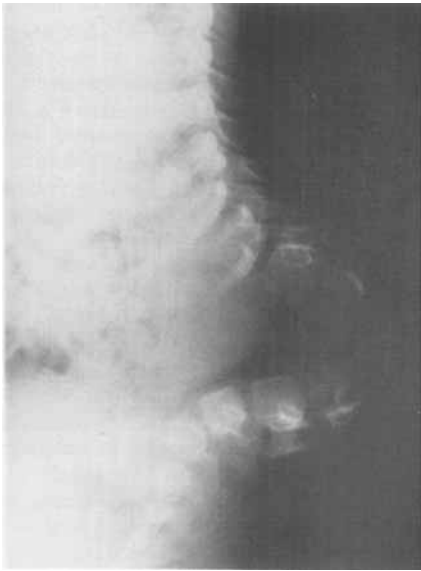


Figure 1. A 4-year-old boy before and after surgery for paralytic kyphosis. This case demonstrates the morphologic effects of the operation; he did not belong to the series reported here.



allowed to stand without any time limit with a whole-body support and leg orthotics, which were coupled to the body jacket. Six months after surgery, unlimited sitting was allowed, and a gradual weaning from the brace was started.

Results

There were no wound infections. In Case 2, the vena cava was perforated peroperatively, but successfully sutured at once through the same posterior approach. The same patient was subjected to another severe complication 2 days after surgery. She had a halo-pelvic device, and one of the screws perforated her

cranium and caused epidural bleeding. Owing to a well functioning cranioperitoneal shunt, the symptoms were masked until she suddenly died.

Two other patients died several years after surgery, but the causes of death were not related to their spinal disorder.

At review, the sitting and lying positions were considerably improved, and none of the patients had pressure sores during the follow-up period. All the patients were satisfied with the results. Radiographically, there was complete bony union in all the patients.

The correction of the kyphosis was good (Table 1). The mean correction was 65° (17° - 106°). There was some deterioration of the kyphosis during the follow-up period in half of the cases. Thus, the mean permanent correction was 57° (0° - 104°), or 42 percent.

Before surgery, the sacrum had an extreme backward inclination in the sagittal plane. The operation resulted in a considerable correction without deterioration during the observation period (Table 1).

The lumbar scoliosis of the kyphotic area showed no progression before surgery. Further, there was no progression of the curve during the follow-up period. Three patients had a thoracic curve, but none of the curves progressed postoperatively. In 2 patients, a minor thoracic curve appeared during the follow-up period, but no treatment was required (Table 1).

Discussion

Important findings during the follow-up period of our series were that the loss of correction was negligible and that only a minor development of a secondary curve occurred in spite of the relatively short fusion. We did not experience any disadvantages of not fusing the sacrum. It seems reasonable to apply this method of short lumbar fusion even in cases of very young patients, because it does not interfere with growth as much as a long fusion does. Mayfield (1981) advocated late surgery to avoid a possible progression of the curve during follow-up. Our results instead support early surgery to prevent a major rigid kyphosis, as a secondary operation was not necessary in any of our patients. In addition, Lindseth and Stelzer (1979) demonstrated that the permanent results depend on the type of surgical resection, and not on the length of the fusion or the age of the patient. Many of their patients were operated on before the age of 2 years. The fusions were short, and they did not fuse the lumbosacral joint. In spite of this, the loss of correction during their 1-7-year follow-up was not major. Christofersen and Brooks (1985) also reported a mod-

erate loss of correction after short fusion and minor spinal instrumentation. Because all the severe, untreated kyphotic curves increase with growth, it appears that surgery should be performed early and that the spinal instrumentation should not be extensive.

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