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Complications of scoliosis surgery in children with myelomeningocele

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Abstract The purpose of the present study was to evaluate whether the high incidence of complications in scoliosis surgery in myelomeningocele (MMC) could be attributed to the surgical technique and whether improvements were possible. Between 1984 and 1996, 77 patients with MMC and scoliosis were treated surgically. The clinical and radiological follow-up ranged from 1 to 10 years with a mean follow-up of 3.6 years. The mean age at time of surgery was 12 years 8 months. The average preoperative scoliosis measured 90.20° and was corrected by 47%. The first four patients were stabilized with Harrington rods after anterior correction with a Zielke device (group 1). Twenty-five patients were operated only from posterior, using Cotrel-Dubousset (CD) instrumentation (group 2). In 13 patients an anterior release and discectomy was performed prior to CD posterior instrumentation (group 3). In 26 patients (group 4) this was combined with an anterior instrumentation. The 9 patients of group 5 had congenital vertebral malformations which made a special treatment necessary. Complications could be divided into hardware problems, such as implant failure, dislocation or pseudarthrosis, infections, anesthetic, and neurologic complications. Hardware problems were seen in 29% of all patients. More hardware problems were seen with the Harrington rod (75%) and after solitary posterior instrumentation (30%). The occurrence of pseudarthrosis was dependent on the surgical technique, the extent of posterior spondylodesis, and lumbosacral fusion. Patients with hardware problems had a mean loss of correction of 49% compared to 13% in the other patients. Depending on the different surgical techniques a loss of more than 30% was seen in 12–75% of the cases. Early postoperative shunt failure occurred in four cases; delayed failure – after more than 1 year – in three cases. One patient died within 1 day due to an acute hydrocephalus, another died after 2½ years because of chronic shunt insufficiency with herniation. Wound problems were not dependent on the surgical technique, but on the extent of posterior spondylodesis and the lumbosacral fusion. Based on this analysis we believe our current practice of instrumented anterior and posterior fusion is justified. Further, we are very careful to check shunt function prior to acute correction of spinal deformity.

Key words Scoliosis · Myelomeningocele · Complications · Spina bifida · Surgical treatment

Introduction

A major problem confronting children with myelodysplasia is the progressive scoliosis [4, 7]. The goal of any treatment is a straight spine centered over a level pelvis [12], in order to enable sitting, to prevent pressure sores, and to increase pulmonary function [5]. Operative treatment of spinal deformities in myelomeningocele (MMC) is difficult and associated with many complications [11]. The purpose of this study was to review our results in the surgical management of scoliosis in MMC.

Material and methods

Between September 1984 and July 1996, 77 patients with a mean age of 12.9 (± 2.2) years were operated. Age ranged from 6 years and 2 months to 18 years and 7 months; 70.1% of the patients were under 14 years of age. Forty-six of the children were girls and 31 boys. Over the years the surgical method changed so that patients could be divided into five groups:

Group 1: Prior to 1986 four patients were stabilized with Harrington rods, usually combined with a ventral derotational spondylodesis (VDS) using the Zielke device.

Group 2: After 1986 Cotrel-Dubousset (CD) instruments were used for all posterior instrumentations. The 25 patients of group 2 were operated and instrumented only from posterior.

Group 3: In these 13 patients an anterior release with discectomy was performed prior to posterior fusion and stabilization with CD instrumentation.

Group 4: In 26 patients posterior fusion and stabilization followed anterior derotation and spondylodesis (VDS) according to Zielke.

Group 5: These nine patients had severe kyphoscoliosis and/or congenital vertebral deformities, each making unique instrumentation techniques necessary. Therefore this group was excluded from statistical analysis concerning the influence of the surgical procedure.

The distribution and characterization of the patients is summarized in Table 1.

In cases of combined anterior and posterior surgery without anterior instrumentation, halo traction was used until posterior surgery, which was performed 14 days after anterior surgery. Bone graft for posterior fusion was taken from the iliac crest and supplemented by bank bone. For anterior fusion a resected rib was used as bone graft.

The average scoliosis measured 90.2° (± 23.7°) preoperatively and 42.7° (± 16.3°) postoperatively. The apex of the scoliosis lay at L1 in 31.2% of the patients, in 35% at T12 or above. Only in 6% was it located above T9. The level of paralysis lay at or above T12 in 14.3% of the patients.

The mean length of fusion with posterior instrumentation was 12.7 vertebrae and with anterior instrumentation, 5.4. In 71% of the cases S1 was included. Postoperatively patients wore a brace for a mean of 10.9 (± 7) months. They were hospitalized for an average of 104 (± 48) days. Patients with pathologic kyphosis requiring a columnotomy or kyphectomy were not included in this study. In all cases scoliosis was the predominant problem.

Statistics

Statistical evaluation was performed with SPSS. The distribution of nominal scaled parameters, like complications, within the surgical groups was evaluated by crosstabs using Pearson's χ^2 test. The comparison of mean values was performed with Levene's *t*-test for two groups and with the univariate ANOVA using the Turkey-B test for more than two groups, e.g. the mean preoperative scoliosis and correction within the five groups. A significant difference was accepted at $P < 0.1$. Between groups there was no significant difference in curve magnitude ($P > 0.1$). Even when patients were divided into those with severe scoliosis (> 90°) and those with moderate scoliosis (90°) no differences were visible.

Results

One or more complications were documented in 52.9% of the patients. These problems could be divided into major groups, such as hardware problems, shunt failures, infections and anesthetic complications. No significant difference in the overall appearance of complications could be seen related to the groups. Complications were seen in 60% of the patients over 14 years of age and in 48.8% under the age of 14 ($P > 0.1$).

Hardware problems were seen in 29.8% of the cases. They were significantly more frequent in patients stabilized with a Harrington rod (75%). Where CD instrumentation had been used, they were seen in 28.0% (group 2) to 30.8%

Table 1 Characteristics of patients (*VDS* anterior derotation and spondylodesis, *CD* Cotrel-Dubousset instrumentation)

	Group 1: VDS + Harrington posterior ($n = 4$)	Group 2: posterior CD ($n = 25$)	Group 3: anterior release + posterior CD ($n = 13$)	Group 4: VDS + posterior CD ($n = 26$)	Group 5: congenital malformations ($n = 9$)	Total ($n = 77$)
Mean age (years + month)	14 ± 1.5	12.7 ± 2.6	13.9 ± 1.8	12.5 ± 1.9	11.8 ± 2.4	12.9 ± 2.2
Mean angle of scoliosis						
Preop.	84.5°	79.5°	103.2°	94.8°	93.2°	90.2°
postop.	48°	38°	49.4°	38.4°	54.8°	42.3°
Mean no. of vertebrae fused	10.5	12.5	12.1	14	11.7	12.7
S1 integrated	75%	56%	61%	92%	67%	71%
Mean time in hospital (days)	141	93.5	92.2	118	90.3	104.3
Mean time in corset (months)	12	14	13.5	8.3	7.3	10.9

(group 3). With anterior stabilization the frequency of those complications was reduced to 15.4% ($P < 0.1$ in Pearson's test). Rod breakage occurred in three patients: two in group 1 and one in group 4. In three patients the rod dislocated; in one patient in a cranial direction and in two patients in a sacral direction. In 17 patients (22%) a pseudarthrosis or screw loosening could be noticed on radiographs, and in three patients this was associated with infected hardware. Hardware problems were found in 40% of children over 14 years and 21% of those under 14 years ($P < 0.1$).

Patients with hardware problems had a mean preoperative scoliosis of 92.1° and were corrected by an average of 55.9% (47.6°). In the remaining 54 patients where hardware was not a problem, the curves were similar in magnitude (89.7%) and correction (53.9%). No significant difference could be found ($P > 0.1$; independent samples *t*-test). However, patients with a preoperative curve of over 90° had hardware problems in 32.1% while those with curves less than 90° had problems in 23.1% ($P > 0.1$).

Patients with S1 included in the fusion had a mean preoperative scoliosis of 92.4°, which was corrected by 54.6% (50.1°) and had a mean postoperative loss of 20.8% (10.1°). Those without fusion of S1 had a mean preoperative scoliosis of 84.7°, were corrected by 53.5% (46.5°) and had a mean loss of 23% (11.7°) ($P > 0.2$ in the independent *t*-test). Where S1 had been included in the fusion, pseudarthrosis occurred in 24.5% of the cases, but only in 5.3% of the other patients ($P < 0.1$ in Pearson's test).

From 1991 on, the lumbosacral junction was instrumented with transpedicular screws in L5 as well as in S1. This reduced the incidence of pseudarthrosis from 32.3% to 7.9% ($P < 0.1$).

Hardware problems were associated with loss of correction. Patients with hardware problems had a mean loss of 48.7% (21.7°), patients without hardware problems of 12.5% (6.5°). The mean loss in patients with pseudarthrosis was 39.6% (19.7°). These differences were highly significant ($P < 0.01$). Eighteen patients (27.7%) had a loss of more than 30%. Of these, 72.2% had a hardware problem, while only 10.6% of those without a problem were in this group ($P < 0.1$).

Loss of correction was associated with operative technique: 75% of the patients in group l had a loss of over 30%, but only 12% of the patients of group 4 (anterior and posterior instrumentation) and 31.5% of those with posterior instrumentation alone (groups 2 and 3) (Fig. 1). These differences were statistically significant ($P < 0.05$ in Pearson's test). Even if the 30 patients with hardware problems were excluded, this effect could be confirmed. In the remaining 47 patients without hardware problems there was a significantly higher percentage of deterioration of the correction of the axis in group 1 (100%) and group 2 (40%) compared to groups 3 and 4 (both 20%) ($P < 0.1$).

Infections occurred in 15 patients (19%), in three instances associated with a fistula. In five patients a "local flap" and in one patient partial removal of the instrumentation due to inner decubitus became necessary. Deep infection within 6 months led to removal of all hardware in two patients. Of three late infections, two required hardware removal and one local treatment of an abscess. Infections were more frequent in patients over 14 years of age (30% vs 14.9%). Patients with wound healing problems had a mean preoperative scoliosis of 96.4° and were corrected by 50.6% (49°), while those without infection had a mean preoperative scoliosis of 88.9° and were corrected by 55.2% (49°). This was not a significant difference ($P > 0.1$). If the fusion included S1, wound infections were seen in 24.5% of the cases, if S1 was not included, only in 5.3% ($P < 0.1$). The mean extent of posterior fusion in patients with infection was 13.3 vertebrae, of those without, 11 vertebrae ($P < 0.05$).

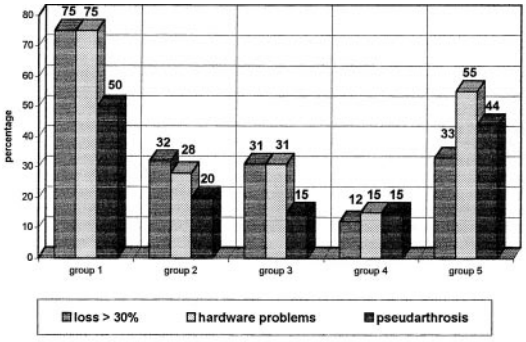

Fig. 1 Hardware problems and loss of correction

In nine patients (12%) insufficiency of the ventricular shunt led to a neurosurgical treatment after correction of the scoliosis, in five of them within a 3-month period and in the other four after more than 1 year. One patient died immediately after posterior instrumentation and correction of 75° (74.3%). He developed an acute hydrocephalus 8 h after surgery. Another patient died 2½ years after posterior instrumentation and correction of 25° (41.7%) due to chronic compression of the brain stem in the foramen magnum.

Patients with postoperative shunt insufficiency had an mean correction of 48.8° compared 49.2° in those without ($P > 0.9$). Mean preoperative scoliosis was 99.0° in patients with shunt insufficiency and 89.4° in those without shunt problems ($P > 0.1$). No influence either of the apex of the scoliosis or the level of paralysis could be found. All patients with shunt insufficiency were younger than 14 years ($P < 0.1$).

Four anesthetic complications were documented. Two cases of severe dehydration as a result of long operating time and blood loss were reported, one of them leading to postoperative tachycardia. In one patient reintubation was necessary, and in one patient a pleural effusion needed to be drained.

Discussion

The correction of scoliosis in patients with MMC is associated with many risks [11, 14]. Grossfeld et al. [8] re-

ported 7.5% major and 33.4% minor complications, Luque [13] 61%, and Ward et al. [20] 58% complications. Our overall complication rate of 52.2% led us to review our approach. Most complications were minor and too infrequent to permit a statistical evaluation. Of those frequent enough to allow it, hardware failure, pseudarthrosis, infection, and shunt insufficiency were the most important.

Age

Grossfeld et al. [8] reported an influence of age on the appearance of major and minor complications in anterior procedures (but did not investigate hardware failures). We could not find any overall influence of age, but it was statistically significant that hardware problems were more likely to be seen in older and shunt insufficiency was more frequent in younger patients. With a mean age of 12 years 8 months, our patients were operated at a similar age to those reported by other authors [8, 11, 15]. However the timing of the operation is not determined by age, but by other parameters such as curve magnitude, sitting imbalance, and pulmonary compromise [1, 4, 5, 16].

Preoperative scoliosis and correction

The mean preoperative scoliosis measured 90.34° and was corrected by 54.3%. These values were similar to those given in the literature [2, 9]. According to Hopf et al. [9], patients with MMC have an approximately 30% greater preoperative angle than those with idiopathic scoliosis. Our goal is to stabilize the spine before the curvature exceeds 70°, but often patients are referred late. We therefore recommend that any patient older than 10 years with progressive scoliosis should be considered a candidate for surgical correction.

The preoperative scoliosis and amount of correction did not differ between the different groups. No influence on the occurrence of hardware problems or deterioration of the curvature could be found. Similarly these parameters had no impact on the frequency of infections or on early or late postoperative shunt insufficiencies. Patients with problematic wounds had larger preoperative curvatures, though this was statistically insignificant.

Surgical technique

Another important factor is the surgical technique. It clearly influences the incidence of hardware problems, pseudarthrosis, infection, and loss of correction.

No statistical influence of the technique of fusion and instrumentation on the occurrence of infections could be found. Comparison of infection rates in the literature is complicated by the wide range of diagnosed infections. Siriam et al. [18] reported an infection rate of 21%, Hull et al. [10] of 43%. Hopf et al. [9], who only performed anterior spinal fusion, had only one superficial infection in 50 patients.

No statistical correlation between the surgical groups and the frequency of insufficiencies of the ventricular shunt could be seen.

The impact of the instrumentation on the correction and stabilization of the scoliosis has previously been described by other authors. Masur et al. [14] reported 20% hardware failure and 33% pseudarthrosis if the Harrington rod was used alone. If anterior Dwyer fusion was added, hardware failures decreased to 9% and pseudarthrosis to 11%. Ward et al. [20] reported 19 different hardware problems in 38 patients, Bonnet et al. [3] reported 34% hardware problems, Kumar and Townsend [12] 26% pseudarthrosis or hardware problems, and Keessen et al. [11] 24.6% failures of instrumentation.

We found hardware-related complications in 29.8% of our 77 cases, of which 17 cases (22%) were screw loosenings and pseudarthroses. They were significantly influenced by the surgical technique or device. Our experience with the Harrington rod was so disappointing that the procedure was abandoned after four patients. Three of the four suffered from loss of correction of 40% or higher, requiring reoperation. In two patients dislocation or breakage of the rod was the cause of the deterioration. Use of CD instrumentation lowered the occurrence of such problems to 28%. Anterior release and discectomy followed by CD instrumentation was no better than posterior CD alone (hardware-related complications 31%), but anterior instrumentation did reduce the incidence of hardware-related complications (15%).

Loss of correction coincided with hardware problems. Patients without hardware-related complications had an average postoperative loss of 12.5%, those with hardware-related complications of 48.7%, and those with pseudarthrosis 39.6%. Among patients with hardware-related problems a higher incidence of loss of correction, of over 30%, was found.

The type of surgical procedure affected the prevalence of loss of correction and this was irrespective of hardware problems or pseudarthroses.

Similar results of Harrington instrumentation on patients with MMC were reported by other authors. Siriam et al. [18] reported pseudarthrosis in 42% and Hull et al. [10] in 76% of their patients. Osebold et al. [17] lowered the pseudarthrosis rate from 46% to 23% by adding Dwyer or Zielke's anterior fusion. Nevertheless, Ward et al. [20] proclaimed that "neither the presence of anterior instrumentation nor the type of posterior instrumentation is an important determinant for obtaining fusion". We would disagree with this, because adding anterior instrumentation did significantly influence the prevalence of hardware failures and loss of correction in this study. Anterior fusion alone is not sufficient to achieve solid fusion in MMC [14, 19, 20].

Extent of spondylodesis

Although most pseudarthroses were seen in the lumbosacral junction, the extent of instrumentation and the inclusion of S1 did not seem to influence the amount of initial correction or loss of correction [6]. Patients in which the decision of fusing S1 was undertaken had a slightly greater preoperative deviance, though not statistically significant. Fusion down to S1 led to five times more pseudarthroses. As a consequence of the high rate of loosening and pseudarthrosis in the lumbosacral region we now perform a bilateral transpedicular instrumentation of L5 and S1. The prevalence of wound infections was clearly influenced by the extent of the posterior fusion and fusion to the sacrum. One possible reason may be that lumbosacral fusion often leads to a space between the spine and the skin around the old scar resulting from the sac closure. This induces a seroma or hematoma, which may be the reason for the higher incidence of wound healing problems and infections. We now put an additional drain in this region. In our review of the literature we found nothing that looks at the extent of the fusion in relation to wound healing problems or other complications.

Conclusions

Because of the one patient who died shortly after correction of the scoliosis from shunt malfunction, all patients are now evaluated neurosurgically to confirm shunt function.

Hardware problems and loss of correction are determined by the surgical technique. Hardware failure was responsible for excessive loss of correction. Therefore, we draw the conclusion that only combined anterior and posterior instrumentation can stabilize patients with MMC to allow solid fusion.

Because most pseudarthroses were seen at the lumbosacral junction, we now perform bilateral transpedicular fixation of L5 and S1. Additionally, patients with lumbosacral fusion are given a Stryker bed for 4 weeks postoperatively, and all patients are immobilized in a brace for at least 6 months.

Wound healing problems are influenced by the extent of posterior instrumentation. Drainage of the lumbo-sacral seroma may help reduce infections and wound healing problems in this region.

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