Surgery of lumbar and thoracolumbar scolioses in adults over 50. Morbidity and survival in a multicenter retrospective cohort of 180 patients with a mean follow-up of 4.5 years

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Adult scoliosis; Complications; Kaplan-Meier survival analysis; Instrumented spinal fusion

Summary
Introduction: The increasing life expectancy of the population and the improvement in surgical and medical management of elderly patients mean that the indication for surgical treatment of adult lumbar and thoracolumbar scolioses has been extended. However the benefit/risk ratio of these procedures is still under debate.

Materials and methods: We reviewed 180 patients, mean age 63 years old with a minimum follow-up of 1 year in a retrospective, continuous, multicenter study. The incidence rate of complications from surgery and the factors influencing their frequency were evaluated by univariate and multivariate analysis. The risk of a second operation was studied by actuarial survival analysis.

Results: After a mean follow-up of 4.5 years, 79 patients (44%) presented with at least one complication, including 32% with a serious complication. The most frequent complications were mechanical. The risk factors were medical co-morbidities, the extent of fusion and the extent of the preoperative sagittal imbalance. A second operation was necessary in 25% of patients at 1 year and 50% of patients at 6 years of follow-up.
Introduction

The desire of the elderly population to have a better quality of life and the increase in their life expectancy have pushed surgeons to evaluate the pertinence of the surgical treatment of adult scoliosis.

Smith et al. [1,2] compared patients who received medical and surgical treatment and concluded that there was a significant improvement after surgical treatment. Li et al. [3] compared 34 patients who underwent surgery and 49 patients who received medical treatment, all over 65 years old and also concluded that there was a significant improvement in surgical patients. Finally, Bridwell et al. [4] reported an improvement in the quality of life in patients who underwent surgery in a study with 160 patients and a level of evidence II. However, several studies have reported a significant rate of complications with surgery whose frequency varied greatly (9%–66%). Thus, it is essential to obtain a benefit/risk ratio to determine the clinical improvement for the patients in relation to the risks. Also, an evaluation of the predictive factors for developing a complication and the risk of a second operation in the years after surgery must be determined before surgical management can be proposed. The latter notion of the survival of the intervention has only been evaluated in adults in one short series [5] including various deformities.

The aim of this retrospective continuous and multicenter study was to describe the complications of surgical treatment for lumbar or thoracolumbar scoliosis in adults over the age of 50, to define the incidence rate, to determine the factors that could influence the risk of developing these complications, and to evaluate the risk of requiring revision surgery over time based on survival analysis.

Materials and methods

Patients

Inclusion criteria in this series were patients aged 50 or older, who underwent surgery for lumbar or thoracolumbar scoliosis (highest instrumented vertebra between T11 and L5), that appeared to be idiopathic, progressive (scoliosis which first appeared during the period of growth) or de novo (scoliosis which developed after skeletal maturity on a previously balanced spine), whatever the functional symptoms and type of surgery. The minimum follow-up was 12 months.

Discussion: Studies in the literature show that functional results are better with surgical treatment than with medical treatment in the management of thoracic spine and thoracolumbar deformities in patients over 50 years old. An objective assessment of this deformity and associated co-morbidity should make it possible to reduce the rate of complications for this type of surgery.

Level of evidence: Level IV.

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Variables evaluated

Four types of variables were included: variables in relation to the patient, the spinal deformity, the surgical procedure and any complications.

Besides the usual epidemiological variables, (age, sex, body mass index) factors of co-morbidity were evaluated by the ASA, Linn and Gurel scores (Cumulative Index Rating Scale [CIRS]) [6,7].

The preoperative radiographic analysis of the deformity was based on two full body standing AP and lateral radiographs using Optispine™ software. The following were evaluated: the Cobb angle of the major curve on the AP view, the usual pelvic and spinal parameters on the lateral view (pelvic incidence, sacral slope, pelvic version, maximum thoracic kyphosis, maximum lumbar lordosis). On the sagittal plane, overall spinal balance was evaluated by the position of the vertical line running through the center of C7 in relation to the posterior side of S1 (Fig. 1, the distance d2 was considered to be negative when this vertical line passed behind the posterior of C7). To avoid errors due to variations in the enlargement of radiographs, this distance was adjusted to the distance measured between two vertical lines, one passing through the posterior of S1 and the other through the center of the two femoral heads (Fig. 1, distance noted d1, was considered negative when the vertical line passing by the posterior of S1 was behind the femoral heads). The relationship between d2 over d1, called the global sagittal balance index, evaluated global spinal balance on the
sagittal plane. The higher and more negative this index was, the greater the sagittal imbalance. Because a satisfactory global balance could be the result of compensation mechanisms (increased pelvic version, decreased thoracic kyphosis, etc.), we considered that the sum of the global sagittal balance index + pelvic version (after standardization of these two series of values) was a better reflection of sagittal plane balance: normal balance, so-called compensated imbalance and so-called decompensated balance. This new index was called the compensated sagittal balance index. The following were taken into account for the surgical procedure: extent of fusion (four vertebrae or less, between five and 11 vertebrae), additional procedures: nerve root decompression, transpedicular osteotomy or one or several isthmic osteotomies, anterior fusion in addition to posterior fusion (whatever the method used) and/or finally inclusion of the sacrum in the area of fusion.

To simplify the presentation of results, the different peri- or postoperative complications observed were grouped into four categories: general, neurological, mechanical and infectious.

Methods of analysis

We first presented a global analysis of peri- and postoperative complications: incidence rate, and description.

We then evaluated the influence of factors that could modify the frequency of complications. The following risk factors were taken into account: age, factors of co-morbidity based on the ASA and CIRS scores, the extent of fusion, nerve root decompression, transpedicular osteotomy or one or several isthmic osteotomies, supplementary anterior fusion, inclusion or not of the sacrum in the area of fusion, AP view Cobb angle of the major curve, pelvic incidence, pelvic version, sacral slope, the global sagittal balance index, and the compensated sagittal balance index. The influence of these confounding factors on the risk of developing a complication was first studied independently, then globally (univariate and multivariate analysis). All of these analyses were performed with Stata 11 software.

Finally, the risk of undergoing additional surgery due to complications in relation to the duration of follow-up was evaluated with survival analysis. An actuarial method was used: the event, which was taken into account, was the development of a severe complication, and the chosen time interval was a semester. The following were defined as severe complications: neurological complications except for dural tears, infectious complications, mechanical complications, even if they did not require additional surgery and severe general complications (stopping the surgical procedure due to severe bleeding, postoperative myocardial infarction, hypovolemic shock, etc.). The influence of these same confounding factors were also studied in relation to this risk.

Results

The cohort

The series included 180 patients, 88% were women: mean follow-up was 4.5 years (range 1–11). The mean age was 63 (range 50–82). The ASA score was 2 in 88% of patients. The mean CIRS score was 5.2 (±4.4). The mean AP view Cobb angle of the major curve was 51° (±19), this was significantly higher (P = 0.0001) in cases of thoracolumbar scoliosis (56 ± 19) than lumbar scoliosis (44 ± 18). The mean pelvic incidence was 55° (±10), the mean pelvic version was 25° (±9.8), the mean sacral slope was 30° (±9.2) and the global sagittal balance was −0.97 (±1.07). Thus, the pre-operative assessment shows that the average patient had anterior pelvic tilt. None of the patients had undergone prior surgery. The posterior approach was used in 72% of patients, the anterior approach in 10% and two-step surgery was performed in 18% with a posterior and anterior approach. The mean number of vertebrae included in fusion was 8 (±4), it was 4 or less (short fusion) in 27 cases, greater than 11 in 29 cases (long fusion) and between 5 and 11 (intermediate fusion) in 124 cases. The mean Cobb angle of the major curve was heterogeneous among the three groups (P < 0.001). The two groups of patients with (55% of the cohort) and without sacral involvement were comparable for age, location of the major curve and its size.

Analysis of complications

At least one complication was identified in 79 patients (44% of the cohort), including 46 patients with one complication, 24 with two complications and nine patients with more than two complications. A general complication was found in 29 patients (16.1%), an infectious complication in eight patients (4.4%), a neurological complication in 15 patients (8.2%) and a mechanical complication in 44 patients (24.4%). According to the definition, 58 patients (32%) had a severe complication.

Forty-three general complications were observed in 29 patients, and are summarized in Table 1. No deaths or ocular complications were observed. Thromboembolic complications were frequent (3%) despite systematic prophylactic treatment. In two cases, surgery had to be discontinued because of perioperative blood loss. Postoperative psychiatric disorders were also frequent (4.5%). No severe gastrointestinal complications occurred. Ten patients (5.5%) had a surgical site infection. In eight cases (4.4%), this occurred before the third postoperative month and in two cases after (delayed infection). All of these patients underwent a second intervention and two underwent a third because of persistent and rapid recurrence of infection. The germ could not be identified in four cases. In four cases, it was a staphylococcus infection and, in two cases, a gram negative bacteria (Klebsiella and Escherichia coli). In one out of two cases, this surgical site infection was complicated by pseudarthrosis requiring additional surgery a mean 3 years after initial surgery.

Seventeen neurological complications were observed in 15 patients. This included a dural tear in six cases and a neurological disorder secondary to surgery in 11 cases. In three cases, this included objective nerve disorders, in five cases peripheral motor disorders, cauda equina syndrome in one case and a central nervous system disorder in two cases. Four patients underwent a second operation due to these complications. In ten cases, postoperative complications resolved without sequella, in three cases sequella from this
neurological complication were noted at the final follow-up. The cause of these neurological complications, secondary to surgery, were clearly identified in three cases. In two cases, it was due to secondary nerve compression, one by a bone graft, the other due to insufficient nerve decompression. In one case, it was due to a compression fracture, which developed at the top of the area of fusion 1 year after surgical treatment.

The most frequent complications were mechanical. Sixty-eight mechanical complications were identified in 55 patients. In eight patients, this complication was observed within 3 months after surgery (early mechanical complication). A second intervention was necessary in each of these cases. In five cases, it involved immediate spinal imbalance, in two cases early loosening of instrumentation and in one case early rod breakage. One or several mechanical complications developed in 47 patients more than 3 months after surgery (late mechanical complications). This included pseudarthrosis in 35 cases (18.5%). Twenty-five of these required additional surgery and ten were simply followed-up, and had not required further surgery at the final follow-up. Postoperative imbalance developed gradually in five cases with no clear area of pseudarthrosis. All required additional surgery. Twelve kyphoses developed above the area of fusion and additional surgery was necessary in six cases. Finally in eight cases (4.4%), progression of the curve was observed under the area of fusion requiring revision surgery.

### Table 1 General complications (29 patients, 43 complications).

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestives</td>
<td></td>
</tr>
<tr>
<td>Postoperative occlusion</td>
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</tr>
<tr>
<td>Postoperative even</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac and pulmonary</td>
<td></td>
</tr>
<tr>
<td>Postoperative myocardial infarction</td>
<td>1</td>
</tr>
<tr>
<td>Severe high blood pressure</td>
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</tr>
<tr>
<td>Perioperative hypovolemic shock</td>
<td>1</td>
</tr>
<tr>
<td>Atelectasia</td>
<td>2</td>
</tr>
<tr>
<td>Phlebites</td>
<td></td>
</tr>
<tr>
<td>Phlebitis</td>
<td>3</td>
</tr>
<tr>
<td>Phlebitis and pulmonary embolism</td>
<td>2</td>
</tr>
<tr>
<td>Psychiatric</td>
<td></td>
</tr>
<tr>
<td>Postoperative confusion</td>
<td>8</td>
</tr>
<tr>
<td>Transfusion</td>
<td>0</td>
</tr>
<tr>
<td>Iatrogenic</td>
<td></td>
</tr>
<tr>
<td>Peripheral nerve compression</td>
<td>2</td>
</tr>
<tr>
<td>SIADH</td>
<td>3</td>
</tr>
<tr>
<td>Anticoagulant</td>
<td>1</td>
</tr>
<tr>
<td>Infectious</td>
<td></td>
</tr>
<tr>
<td>Pneumopathies</td>
<td>2</td>
</tr>
<tr>
<td>Urinary infection</td>
<td>12</td>
</tr>
<tr>
<td>Diverse revision surgeries</td>
<td></td>
</tr>
<tr>
<td>Surgery stopped due to bleeding</td>
<td>2</td>
</tr>
<tr>
<td>Opening of scar</td>
<td>1</td>
</tr>
</tbody>
</table>

### Analysis of factors influencing the risk of complications

The relationship between the risk factors evaluated (taken into account independently) and the development or not of a complication is summarized in Table 2. Four variables were significantly associated with the development of complications; co-morbidities, the extent of fusion, inclusion of the sacrum in the fusion and the degree of preoperative sagittal imbalance. The development of a complication was significantly associated with a greater number of factors of co-morbidity, long fusion, inclusion of the sacrum in the fusion and finally, preoperative sagittal imbalance, which was even more significant if it was decompen-sated (that is associated with increased pelvic version).

When all of the factors studied were taken into account (logistic regression analysis), three factors were significantly associated with the development of a complication: factors of co-morbidity identified with the CIRS ($P = 0.002$), sagittal

### Table 2 Risk factors for developing a complication (univariate analysis).

<table>
<thead>
<tr>
<th>Factor studied</th>
<th>Significance</th>
<th>P</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>ns</td>
<td>0.357</td>
<td>t test</td>
</tr>
<tr>
<td>CIRS</td>
<td>s</td>
<td>0.001</td>
<td>t test</td>
</tr>
<tr>
<td>Extent of the area of fusion</td>
<td>s</td>
<td>0.0001</td>
<td>Chi²</td>
</tr>
<tr>
<td>Intermediate/short</td>
<td></td>
<td>0.028</td>
<td>3.2</td>
</tr>
<tr>
<td>Long/short</td>
<td>s</td>
<td>0.0001</td>
<td>13.8</td>
</tr>
<tr>
<td>Sacral involvement</td>
<td>s</td>
<td>0.012</td>
<td>1</td>
</tr>
<tr>
<td>Supplementary anterior fusion</td>
<td>ns</td>
<td>0.102</td>
<td>Chi²</td>
</tr>
<tr>
<td>Associated nerve decompression</td>
<td>ns</td>
<td>0.512</td>
<td>Chi²</td>
</tr>
<tr>
<td>Transpedicular osteotomy</td>
<td>ns</td>
<td>0.169</td>
<td>Chi²</td>
</tr>
<tr>
<td>Ostéotomie transisthémique</td>
<td>ns</td>
<td>0.513</td>
<td>Chi²</td>
</tr>
<tr>
<td>Cobb (main curve, frontal)</td>
<td>ns</td>
<td>0.056</td>
<td>t test</td>
</tr>
<tr>
<td>Pelvic incidence</td>
<td>ns</td>
<td>0.258</td>
<td>t test</td>
</tr>
<tr>
<td>Pelvic version</td>
<td>ns</td>
<td>0.1</td>
<td>t test</td>
</tr>
<tr>
<td>Overall sagittal balance index</td>
<td>s</td>
<td>0.006</td>
<td>t test</td>
</tr>
<tr>
<td>Compensated sagittal balance index</td>
<td>s</td>
<td>0.001</td>
<td>t test</td>
</tr>
</tbody>
</table>
imbalance studied by the compensated sagittal balance index ($P = 0.025$) and the extent of fusion ($P = 0.002$). The other variables had no influence on the development of complications. The greater the number of co-morbidity factors, the higher the risk of developing a complication; the more significant the proximal junction kyphosis was and the more it was associated with pelvic version, the greater the risk of developing a complication; finally the more extensive the fusion, the greater the frequency of complications (three times more frequent when the short fusion group was compared to the intermediate fusion group and ten times more frequent if the long fusion group was compared to the short fusion group).

Analysis of survival

The results of survival analysis are presented in Table 3 and Fig. 2. The risk of developing a severe complication was fixed at 25% at 1 year, 33% at 3 years and 50% at 6 years. The influence of all the previously mentioned risk factors in the development of a severe complication was studied with the Cox model. The risk of developing these complications was significantly influenced by three factors: the number of factors of co-morbidity ($P = 0.02$), the extent of fusion ($P = 0.035$) and the degree of sagittal imbalance based on the compensated sagittal balance index ($P = 0.045$). The influence of the extent of fusion taken alone is summarized in Fig. 3. The influence of this variable on the risk of developing a severe complication mainly concerns intermediate and long fusions. Each seems to behave differently: long fusion mainly influences complications soon after surgery, while the influence of intermediate fusion is distributed more evenly over time.

Discussion

Numerous studies have reported a high rate of complications with arthrodesis of the lumbar spine. However, comparisons are difficult because the etiologies are generally different. Therefore, we only included studies that evaluated idiopathic or degenerative deformities in adults with a majority of scolioses. However, even with these selection criteria, comparison is difficult because different methodologies were used. Glassman et al. [7] differentiated severe complications, which require additional surgery from benign complications which do not include any long or intermediate term sequella.

In our study, 58 patients (32%) presented with a severe complications. The factors associated with the development of these complications were a high rate of co-morbidities, the extent of arthrodesis and the degree of sagittal imbalance before surgery. In fact, patients requiring complicated surgery with significant co-morbidities had the highest risk of complications. Mok et al. [5] reported a 25.8% rate of second operations in a study of 89 patients with co-morbidities and tobacco use as associated risk factors.

In a study in 46 patients, whose mean age was 67, Daubs et al. [8] reported complications in 37% including severe complications in 20%. The risk factors were in particular, age over 69 and a transpedicular osteotomy. Age increased the risk of developing a complication by nine times, and undergoing a transpedicular osteotomy by seven. In a study in 47 patients, whose mean age was 66, Cho et al. [9] did not find that age or co-morbidities were risk factors for complications.

Survival analyses

Very few analyses have been reported in the literature on this subject. To our knowledge, only two studies have evaluated this variable, although it could be extremely important to help the patient and the surgical team make a decision. In a series of 133 adolescents followed for a mean 16.5 years, Bagot et al. [10] evaluated the risk of undergoing a second operation (for whatever the cause) as 6.1% at 1 year, 17.8% at 5 years and 23.5% at 10 years. For Mok et al., the risk of undergoing a second operation in adults was 13.6% at 1 year, 12.8% at 2 years and 14.8% at 3 years. In our series, the risk at 3 years was 33%. The difference was probably due to the type of scoliosis being treated, the higher mean age in our series (48.5 years versus 63) resulting in a more frequent rate of sacral involvement.

In our study, the extent of fusion significantly affected the risk of requiring a second operation. In fusion of less
than five levels, the risk was 10% at 2 years, and was stable thereafter. In arthrodeses of more than 11 levels, the risk of additional surgery, which was high at first mostly due to pseudarthroses, stabilized after 4 years. On the other hand when fusion included between five and 11 vertebrae, the risk of revision surgery continued to progress after 4 years due to the risk of developing a condition below and especially above the level of fusion. This notion has never been described in the literature.

Neurological complications

The development of neurological complications varies over time. The frequency of these complications was 2.9% for all types of surgical procedures combined for Pateder et al. [11], 3.8% for revisions and 7.4% for fusion of more than ten levels. A transpedicular osteotomy increased this risk [12]. In 2533 cases of degenerative scoliosis, the Scoliosis Research Society (SRS) [13] reported neurological complications in 2.4% of cases: 2.13% were peripheral and 0.2% were central. The rate was lower in idiopathic scoloses (1.45%). A dural tear increased the neurological risk [14], and was more frequent in degenerative scoloses (2.2%) than idiopathic scoloses (0.9%). In our series one third of the patients who presented with a tear also had neurological complications.

Mechanical complications

The development of a compression fracture in the upper part of fusion is one of the most severe complications that can occur because it causes sagittal imbalance of the trunk and may cause neurological complications in long arthrodesis with sacral fusion, O’Leary et al. [15] reported compression fractures in 5%, and 1% of these had neurological complications. The fracture could occur at the highest-level vertebrae of the fusion or in the first free vertebra. Osteoporosis and a high body mass index were identified as risk factors, but not the presence of postoperative sagittal imbalance. Watanabe et al. [16] identified this complication in 2.6% of the patients in their series and noted that fractures that developed in the first free vertebra above the fusion had more severe neurological consequences. Osteoporosis, age, co-morbidities and the extent of sagittal imbalance before surgery were the main risk factors.

Besides compression fractures, sagittal imbalance can develop due to progressive worsening of kyphosis of the entire underlying spinal column. Its frequency was 6/38 for Dewald et al. [17] and 23/99 for Kim et al. [18]. For this same authors, insufficient postoperative correction with a tilt in C7 of more than 5 cm and age older than 55 are risk factors for decapsulation. To prevent the risk of the progression of proximal junction kyphosis, extension to T2 is essential in the presence of thoracic kyphosis or in the absence of muscular control of the dorsal spine. Persistent postoperative imbalance associated with osteoporosis is a potential source of worsening of anterior tilt.

Progressive osteoarthritis in the underlying discs was found in 4.4% of the patients in our series who had to undergo additional surgery. As early as 1998, Balderston et al. [19], unlike Harding et al. [20], noted the degeneration of underlying discs and a correlation between this degeneration and the worsening of lumbar pain. After 9.3 years of follow-up, the latter found that revision surgery was necessary in 11.7% especially in patients with postoperative
imbalance. Edwards et al. [21] found disc degeneration in 61% of 34 patients who underwent arthrodesis up to L5. Kuhns et al. [22] noted that a significant number of patients with disc degeneration had significantly greater anterior tilt than patients with good quality discs. The choice between stopping fusion at L5 or the sacrum is difficult.

Edwards et al. [21] noted that when they stopped at L5, there were degenerated discs in 67%, while when they stopped at the sacrum the rate of pseudarthrosis was much higher with more general complications. Twenty-two percent of patients, in whom fusion stopped at L5, required sacral fusion at 5 years of follow-up.

In our experience, fusion should stop at L5 in younger patients (if L4-L5 is diseased). On the other hand, over the age of 60, extension to the sacrum is preferable, especially if the L5-S1 disc is truly degenerative or with kyphosis. If it is necessary to extend fusion to the sacrum, this is a sign of an advanced degenerative process in patients that are more difficult to manage, which plays a role in increasing morbidity.

Pseudarthrosis is the most frequent complication, and was found in 18.5% of patients in our series, which is comparable to the rate in the literature. Weistroffer et al. [23] reported pseudarthroses in 24% of patients, with only one fourth of these identified after 2 years of follow-up. Kim et al. [24] reported a rate of 24%, which was often diagnosed after 4 years of follow-up. Dewald [17] identified pseudarthroses in 11% of patients over 65 years old. To reduce the risk of lumbosacral pseudarthrosis, it is preferable to obtain fixation on the two S1 pedicles associated with internal fixation of the iliac wing, as well as anterior L5-S1 arthrodesis. However, the value of complete circumferential fusion has not been confirmed in the literature [25]. The risk factors for developing pseudarthrosis are controversial. Kim et al. [24] insist on the importance of insufficient correction with a tilt at C7 of more than 5 cm. For Mok [5] tobacco use or co-morbidities are risk factors, but not for Weistroffer [23].

**General complications**

In our series, none of the general complications resulted in significant sequela but they did increase the length of hospital stay and the cost of management. There were no mortalities. To prevent complications, the preoperative evaluation is very important. Hu et al. [26] recommend careful preparation before proposing surgery, with an investigation of co-morbidities and they also insist upon assessment of nutritional, endocrinial and osteoporotic variables. An evaluation of psychological factors and the family environment is also important.

**Infectious complications**

Infectious complications are divided into early complications before 3 months and late. Studies in young patients report rates varying from 1–6%. In the report from the SRS [27], the rate was 2.8% in idiopathic adult scoliosis, 1.4% in children and 4.1% in degenerative scoliosis. For Mok et al. [28], age and the extent of fusion do not influence the development of this type of complication. There have been more studies in late infections. Several reports [29–33] show that an infection can develop several years after surgery. Slow growing bacteria (Propioni Bacteories Acnes, staphylocoques epidermidis) were more frequent and different from those found in early infections. The causes of these infections can be due to the bulky instrumentation which favors the development of contact bursitis [31]. Soutlanis et al. [32] concluded that rigid structures mainly with screws caused fewer infections because of better stability.

**Conclusions**

The selection criteria in patients in this study (age over 50, relatively homogeneous etiologies), and the method used (survival analysis) identified the real problems associated with the surgical management of adult scoliosis. The results provide the surgical team and the patients with more realistic information on this treatment.

It confirms the importance of mechanical complications and of restoring good trunk balance, in particular lateral. A rigorous analysis of pelvic and spinal variables should improve understanding of the deformity making it possible to propose a satisfactory strategy to reduce the risk of developing complications, in particular proximal junction kyphosis. However, although the rate of secondary surgery is high, the natural progression of this disease is poor and surgical treatment should be considered in patients in pain with progressive, imbalanced scoliosis. The patient should receive complete information with an explanation on the risk/benefits of surgery, which should be considered in relation to the natural history of the disease.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**


Complications of surgery for adult lumbar scoliosis


