·临床研究·

脊柱侧弯合并椎管内病变的一期手术治疗

王凯 吴浩 菅凤增

【摘要】 **目的** 探讨一期手术治疗脊柱侧弯合并椎管内病变的有效性和安全性。**方法与结果** 共6例脊柱侧弯合并椎管内病变患者均完成一期手术治疗，手术成功率为100%。手术时间（470.83±136.20）min，术中出血量1350（625，2150）ml，融合椎体节段（11.00±2.76）个；术后冠状位侧凸角度（19.60±5.94）°，矢状位后凸角度（25.80±10.87）°，均较术前改善（P=0.007，0.005）；脊髓拴系行脊髓拴系松解术，表皮样囊肿、节细胞胶质瘤和椎管内脂肪瘤行椎管内病变切除术，脊髓空洞症不予特殊处理；无神经功能缺损恶化；术后下肢肌力增高，肌张力降低；排尿障碍改善。术后住院（8.83±3.31）d，无一例出现感染、脑脊液漏、脊柱内固定失败、椎弓根螺钉和钛棒断钉断棒等手术相关并发症，无一例死亡。术后随访（7.50±1.22）个月，均无神经功能缺损恶化、迟发性感染和假关节形成，均未出现矫形丢失。**结论** 一期手术可以安全、有效地治疗脊柱侧弯合并椎管内病变，术后神经功能改善，通过截骨可以获得良好的矫形效果。

【关键词】 脊柱侧凸； 脊髓疾病； 神经外科手术

One stage surgical treatment for scoliosis associated with intraspinal abnormalities

WANG Kai, WU Hao, JIAN Feng-zeng

Department of Neurosurgery, Xuanwu Hospital, Capital Medical University, Beijing 100053, China

Corresponding author: JIAN Feng-zeng (Email: fengzengjian@hotmail.com)

【**Abstract**】 **Objective** To evaluate the effectiveness and safety of one stage surgical treatment for scoliosis and coexisting intraspinal abnormalities. **Methods** The data of 6 patients who underwent one stage surgical treatment for scoliosis and coexisting intraspinal abnormalities from October 2016 to January 2017 were retrospectively analyzed. Treatment for intraspinal abnormalities, posterior correction, osteotomy and internal fixation were performed simultaneously. The clinical and radiologic presentations, operative details, complications and postoperative outcomes were evaluated. **Results** The success rate was 100%. The operating time was (470.83 ± 136.20) min and intraoperative bleeding amount was 1350 (625, 2150) ml. Total fusion segments were 11.00 ± 2.76. Both Cobb angle of scoliosis [postoperation (19.60 ± 5.94)° vs. preoperation (59.40 ± 14.31)°, P = 0.007] and kyphosis [postoperation (25.80 ± 10.87)° vs. preoperation (62.40 ± 21.04)°, P = 0.005] were improved after operation. Tethered cords were released and epidermoid cyst, ganglioglioma and lipoma were excised. Syringomyelia was left untreated. No neurological functional defect or worsening was found. Muscle strength of all patients was improved. Muscular tone of 4 patients and difficulty in urination of 5 patients were also improved. The mean hospital stay was (8.83 ± 3.31) d. No severe complications, such as infection, cerebrospinal fluid (CSF) leakage, failed internal fixation, fractured pedicle screws or rods occurred after operation. None of the patients died, or experienced deterioration of neurological function, delayed infection, pseudoarthrosis, or loss correction during the (7.50 ± 1.22) months follow - up. **Conclusions** The one stage surgical treatment for scoliosis and intraspinal abnormalities seems to be a safe and effective approach. Neurological functional defect can be improved after operation. Osteotomy can improve correction result.

【**Key words**】 Scoliosis; Spinal cord diseases; Neurosurgical procedures

研究显示，有20%～58%的先天性脊柱侧弯可以合并椎管内病变[1]，椎管内病变也可以引起神经功能障碍和躯干肌肉力量分布不对称，导致神经肌肉型脊柱侧弯[2]。椎管内病变导致的神经功能障碍可以使脊柱侧弯持续进展，进一步加重神经功能障碍。对于此类患者，既要处理椎管内病变，又要进行脊柱矫形术。经典手术策略分为两期手术，一期先处理椎管内病变，3～6个月后再行二期脊柱矫形

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作者单位：100053 北京，首都医科大学宣武医院神经外科

通讯作者：菅凤增（Email：fengzengjian@hotmail.com）

术[3-5]。采用一期手术治疗脊柱侧弯合并椎管内病变的国外报道尚不多见[1,6-7]，国内亦未检索到相关文献。2016年10月–2017年1月首都医科大学宣武医院神经外科采用一期手术治疗6例脊柱侧弯合并椎管内病变患者，效果满意，现总结报告如下。

对象与方法

一、研究对象

6例采用一期手术治疗的脊柱侧弯合并椎管内病变患者，男性5例，女性1例；年龄14～40岁，平均（21.50±10.37）岁；脊柱侧弯均进行性加重，其中，先天性脊柱侧弯3例，包括楔形椎1例、楔形椎合并分节不良1例、半椎体合并分节不良1例，神经肌肉型脊柱侧弯3例；脊椎MRI显示，脊柱侧弯合并脊髓拴系4例、脊髓空洞症（SM）4例、表皮样囊肿1例、节细胞胶质瘤（GG）1例、椎管内脂肪瘤1例，冠状位侧凸角度38°～74°、平均（59.40±14.31）°，矢状位后凸角度44°～90°、平均（62.40±21.04）°；Risser征2级者1例，3级2例，5级3例；6例上肢肌力和肌张力均正常，6例下肢肌力降低，包括0级3例、2级1例、3级2例，4例下肢肌张力增高；均有排尿障碍。本研究经首都医科大学宣武医院道德伦理委员会审批，患者或其家属均知情同意并签署知情同意书。

二、研究方法

1.术前准备　详细记录患者性别、年龄和神经系统症状。所有患者均于术前行正侧位站立位脊柱X线、脊柱CT和三维重建、脊柱MRI检查以评价脊柱畸形和椎管内病变；均行泌尿系统超声检查以评价泌尿系统是否存在畸形；均行心电图和心脏彩色超声检查以评价心脏功能；均行肺功能测定以评价是否合并严重通气障碍。

2.手术方法　术前根据脊柱影像学检查定位手术融合节段和截骨节段。患者俯卧位，气管插管全身麻醉，显露手术椎体节段、棘突和椎板，若存在脊柱畸形、融合或发育不良，仔细辨认，操作时应谨慎以避免手术器械深入椎管内而损伤脊髓，尤其是棘突和椎板部分缺失患者。根据术中X线定位手术椎体节段无误后，植入椎弓根螺钉，再行X线检查以确认椎弓根螺钉位置。由于脊髓贴近侧弯凹侧椎管，因此，侧弯凹侧植入椎弓根螺钉时应谨慎以避免椎弓根螺钉进入椎管内而损伤脊髓。于手术显微镜下先处理椎管内病变，脊髓拴系患者行脊髓拴系松解术，表皮样囊肿、节细胞胶质瘤和椎管内脂肪瘤患者行椎管内病变切除术，脊髓空洞症患者不予特殊处理。降低脊髓张力后，根据脊柱畸形情况于手术显微镜下行后路截骨矫形术，通常于脊柱侧弯或后凸顶点以及椎体上下节段进行Schwab分级2级截骨，对于先天性脊柱侧弯或严重后凸患者，根据椎体异常类型或矫形要求进行Schwab分级3或4级截骨；完成截骨后，先根据矫形要求预弯钛棒，再植入预弯的钛棒，根据脊柱侧弯和后凸情况进行加压撑开，注意弯棒时兼顾脊柱矢状位序列。最后行自体骨异体骨混合植骨融合术，自体骨源自棘突或截骨时切除的骨质，制备骨颗粒，植入椎板和钉棒周围。所有患者均行术中神经电生理学监测，包括体感诱发电位（SEP）、运动诱发电位（MEP）和肛门括约肌监测。术后引流量＜20 ml/d即可拔除引流管，拔除引流管后可佩戴支具下床活动，术后3个月内均需佩戴支具下床活动。

3.手术疗效和安全性评价　（1）手术疗效：记录手术成功率、手术时间、术中出血量、融合椎体节段、冠状位侧凸和矢状位后凸角度、椎管内病变处理、神经功能、四肢肌力和肌张力等。（2）安全性：术后记录感染、脑脊液漏、脊柱内固定失败、椎弓根螺钉和钛棒断钉断棒等手术相关并发症，随访期间记录神经功能缺损、迟发性感染和假关节形成等手术相关并发症。

三、统计分析方法

采用SPSS 23.0统计软件进行数据处理与分析。呈正态分布的计量资料以均数±标准差（$\bar{x}\pm s$）表示，采用配对t检验；呈非正态分布的计量资料以中位数和四分位数间距[$M(P_{25},P_{75})$]表示。以$P\leqslant 0.05$为差异具有统计学意义。

结　果

6例患者均完成一期手术治疗脊柱侧弯合并椎管内病变，手术成功率为100%。手术时间241～631 min，平均（470.83±136.20）min；术中出血量400～2600 ml，中位值1350（625，2150）ml；手术融合椎体节段7～13个，平均（11.00±2.76）个；术后冠状位侧凸角度12°～26°、平均（19.60±5.94）°，较术前改善（$P=0.007$，表1）；术后矢状位后凸角度10°～40°，平均（25.80±10.87）°，较术前改善（$P=0.005$，表1）；脊髓拴系行脊髓拴系松解术，表皮样囊肿、节细胞胶质瘤和椎管内脂肪瘤行椎管内病变切除术，脊髓空洞症不予特殊处理（图1）。其中3例术后部分

表1 脊柱侧弯合并椎管内病变患者手术前后脊柱侧弯和后凸角度的比较($\bar{x} \pm s$,°)

Table 1. Improvement of Cobb angle of scoliosis and kyphosis after operation ($\bar{x} \pm s$, °)

Time	N	Scoliosis	Kyphosis
Preoperation	6	59.40 ± 14.31	62.40 ± 21.04
Postoperation	6	19.60 ± 5.94	25.80 ± 10.87
t value		5.082	5.584
P value		0.007	0.005

融合腰弯,为26°、28°和15°,较术前改善(58°、55°和38°),1例完全融合腰弯(术前19°、术后9°),1例脊柱后凸和1例胸腰弯无需融合;6例均无神经功能缺损恶化;术后下肢肌力3级2例、4级2例、5级2例,较术前增高(包括0级3例、2级1例、3级2例),4例肌张力降低;术后5例排尿障碍改善,1例经康复治疗后改善,但仍需间断性导尿。术后住院6~14 d、平均(8.83 ± 3.31) d,无一例出现感染、脑脊液漏、脊柱内固定失败、椎弓根螺钉和钛棒断钉断棒等手术相关并发症,无一例死亡。术后随访6~9个月、平均(7.50 ± 1.22)个月,均无神经功能缺损恶化、迟发性感染和假关节形成,未出现矫形丢失。

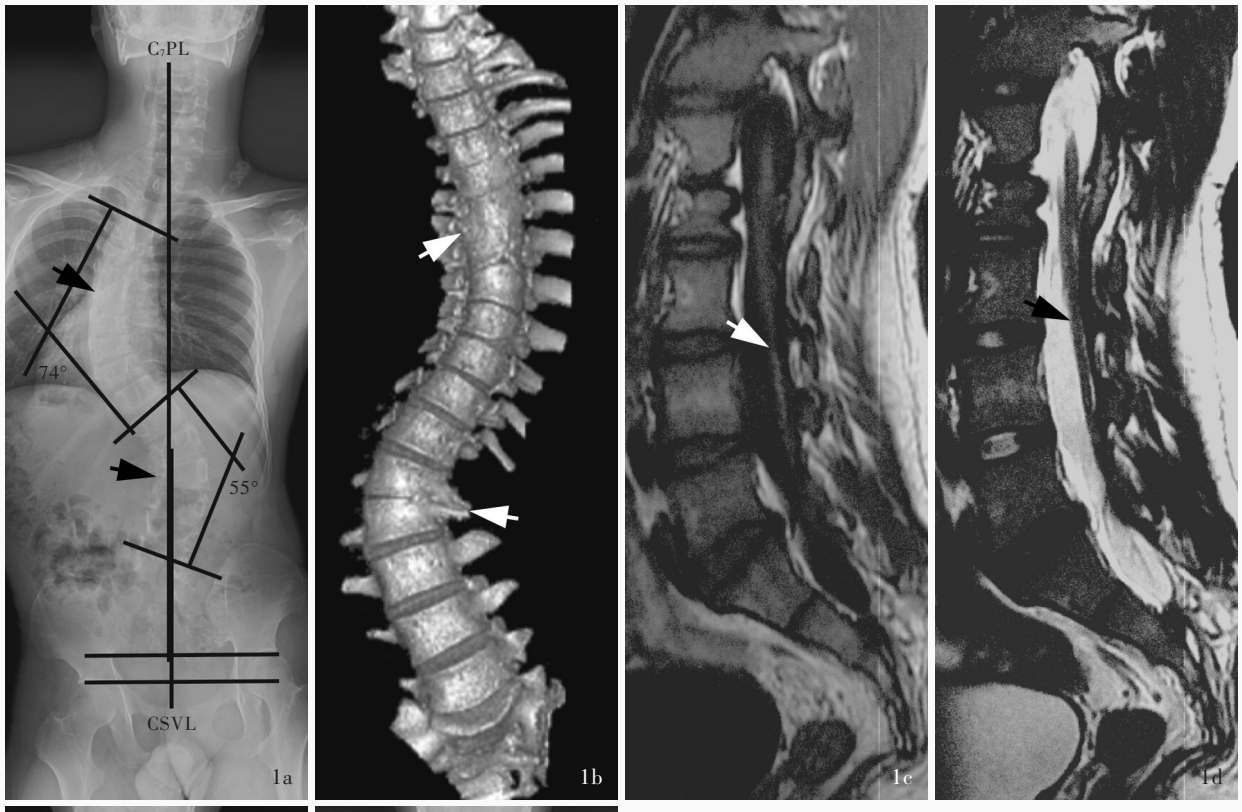
讨 论

先天性脊柱侧弯和神经肌肉型脊柱侧弯均可合并椎管内病变。有文献报道,先天性脊柱侧弯患者术前MRI显示椎管内病变发生率为20%~58%,包括脊髓拴系、脊髓空洞症、椎管内脂肪瘤、畸胎瘤等[3,8]。椎管内病变致神经肌肉型脊柱侧弯临床并不少见[3,9-11],例如,脊髓空洞症因空洞扩张危害脊髓背内侧和腹内侧神经,影响控制躯干平衡的肌肉,导致脊柱侧弯[12-13];脊髓拴系因拴系引起脊髓缺血,使感觉通路异常和椎旁肌肌力不对称,导致脊柱侧弯[13]。亦有观点认为,脊柱侧弯可能是椎管内病变的临床表现之一[3,7]。

若不接受脊柱矫形术,脊柱侧弯可持续加重;此外,椎管内病变也是脊柱侧弯持续加重的危险因素,随着脊柱侧弯加重和椎管内病变进展,神经功能严重损害。因此,脊柱侧弯合并椎管内病变患者常需手术治疗以控制侧弯进展、改善神经功能。然而,在脊柱矫形术中,椎管内病变可能使脊髓过度牵拉,造成神经功能不可逆性损害[1,5-7]。为改善神经功能并减少手术相关神经系统并发症,经典手术策略是先由神经外科医师处理椎管内病变,3~6个月后再由骨科医师行脊柱矫形术[1,3-5,7],该方法可以确保脊髓在脊柱矫形术中不因椎管内病变而受过度牵拉,同时也能在再次手术后观察患者神经功能变化,以利于确认术后并发症原因。但该手术方法也存在一定缺陷:(1)患者将面临多次手术和麻醉风险。(2)一期手术可以增加再次手术显露难度,破坏解剖学标记,从而给二期脊柱矫形术造成困难。(3)一期手术形成的粘连增加截骨矫形难度,也增加医原性神经功能损害风险。另一方面,>40°的脊柱侧弯在手术治疗椎管内病变后仍可能进展,需进一步矫形融合术[6,13]。

随着神经电生理学监测技术的发展,已经能够在术中处理椎管内病变和脊柱侧弯的同时监测神经功能变化[7]。为避免分期手术的缺陷,近年来国外一些医疗中心开始探索一期手术治疗脊柱侧弯合并椎管内病变[1,6-7]。相较于经典的分期手术策略,一期手术治疗此类患者安全、有效,无明显手术相关并发症,手术时间和住院时间更短、术中出血量更少、脊柱矫形效果更好[1,6-7]。本研究一期手术治疗脊柱侧弯合并椎管内病变的手术时间、术中出血量和住院时间均与文献报道相一致[1,6];术后冠状位侧弯和矢状位后凸显著改善,无神经功能缺损恶化,下肢肌力增高,排尿障碍改善,随访期间未出现矫形丢失。因此,对于脊柱侧弯合并椎管内病变的患者,推荐神经电生理学监测下行一期手术治疗。

尽管脊柱畸形和多种椎管内病变是先天性疾病,但其所引起的脊柱侧弯和神经功能缺损症状出现的时间却相对较晚[1]。本组6例患者平均年龄(21.50 ± 10.37)岁,较Mehta等[6]报告的9.6岁和Hamzaoglu等[1]报告的13岁偏大。部分患者出现神经功能障碍后未及时就诊,而是在症状加重或经济条件改善后方就诊,提示临床症状和社会经济因素均可能推迟患者就诊[1]。由于患者就诊时间较晚,骨骼发育相对成熟,脊柱侧弯僵硬(本研究Risser征2级1例、3级2例、5级3例),且先天性脊柱侧弯患者常存在发育异常(本研究楔形椎1例、楔形椎合并分节不良1例、半椎体合并分节不良1例),使脊柱矫形术困难。对于僵硬性脊柱侧弯、严重脊柱后凸患者,截骨矫形术可以获得良好效果[14-16]。本研究均于术中在手术显微镜下行Schwab分级2级截骨,增加脊柱柔韧性,获得更好的矫形效果;对于存在半椎体和分节不良的患者,进一步行Schwab分级



C_7PL, C_7 plumb line, C_7铅锤线; CSVL, center sacral vertical line, S_1铅锤线; PCRL, pelvic coronal reference line, 骨盆冠状位参考线; HRL, horizontal reference line, 水平参考线

图 1 男性患儿, 17 岁, 临床诊断为先天性脊柱侧弯, 脊髓拴系 1a 术前正位站立位X线显示, 胸弯和腰弯显著(胸弯冠状位侧凸角为74°, 腰弯冠状位侧凸角为55°), 躯干经代偿基本平衡, 肩部和骨盆倾斜, 双下肢不等长(双侧股骨头不在同一水平线上), T_{5-7}和L_{1-2}椎体分节不良(箭头所示) 1b 术前CT三维重建显示, T_{5-7}和L_{1-2}分节不良, 可见T_6楔形椎(箭头所示) 1c 术前矢状位T_1WI显示, 脊髓圆锥低位, 位于L_{3-4}椎体水平(箭头所示) 1d 术前矢状位T_2WI显示, 脊髓圆锥低位, 位于L_{3-4}椎体水平(箭头所示) 1e 术后(未穿戴鞋垫)正位站立位X线显示, 胸弯和腰弯矫形效果良好(胸弯冠状位侧凸角为25°, 腰弯冠状位侧凸角为28°), 肩部倾斜改善, 但骨盆倾斜仍存在(骨盆冠状位参考线与水平参考线存在夹角), 躯干矫形后失代偿(C_7铅锤线与S_1铅锤线距离增大) 1f 术后正位站立位X线显示, 穿戴鞋垫使双下肢接近等长(双侧股骨头接近同一水平线), 骨盆倾斜纠正(骨盆冠状位参考线与水平参考线夹角缩小), 躯干平衡恢复(C_7铅锤线与S_1铅锤线距离缩短)

Figure 1 A 17-year-old male was diagnosed as congenital scoliosis associated with tethered cord. Preoperative standing orthophoric X-ray showed severe thoracic curve (Cobb angle: 74°) and lumbar curve (Cobb angle: 55°) with trunk shift compensated, shoulder and pelvic obliquity, leg length discrepancy (the difference between the higher and lower HRL of femoral head), and failure of segmentation of T_{5-7} and L_{1-2} (arrows indicate, Panel 1a). Preoperative 3D-CT of spine showed failure of segmentation of T_{5-7} and L_{1-2} and wedged vertebrate of T_6 (arrows indicate, Panel 1b). Preoperative sagittal T_1WI and T_2WI showed a tethered spinal cord with a low-lying conus at the level of L_{3-4} (arrows indicate; Panel 1c, 1d). Postoperative standing orthophoric X-ray (without shoe pad) showed scoliosis was corrected (Cobb angle: 25° and 28°) and the shoulder obliquity was improved, but the pelvic obliquity remained (the angle between PCRL and HRL) and trunk shift was decompensated (the distance between C_7PL and CSVL increased) due to leg length discrepancy (Panel 1e). Postoperative standing orthophoric X-ray (with shoe pad) showed leg length discrepancy was corrected (the difference between the higher and lower HRL of femoral head decreased) with pelvic obliquity corrected (the angle between PCRL and HRL decreased) and trunk shift compensated (the distance between C_7PL and CSVL decreased, Panel 1f).

3或4级截骨以松解前柱并切除半椎体，术后冠状位侧凸角度改善(63.80±19.02)%、矢状位后凸角度改善(58.80±12.56)%，获得较好的矫形效果。

脊柱侧弯常可以引起身体其他部位异常，包括双肩不等高和骨盆不对称等，这不仅改变脊柱局部解剖学形态，也影响整个身体平衡和对称，行脊柱矫形术时应注意冠状位和矢状位的平衡。骨盆作为躯干力学支持基础，对脊柱平衡和能力代偿起重要作用[17-18]。骨盆旋转与腰弯之间存在相关性，也可以通过腰椎介导协同代偿胸弯[17,19]，行脊柱内固定矫形术后，由于骨盆倾斜和旋转失代偿，可以出现不同程度躯干偏斜，尽管随访中骨盆可以出现再次代偿最终达到平衡[20]，但这种代偿机制也受到脊柱柔韧性的制约，僵硬性脊柱侧弯患者的代偿能力有限。本研究患者脊柱侧弯和后凸均较严重，导致骨盆不同程度旋转和倾斜，其中3例腰弯和骨盆倾斜旋转较严重，若融合腰弯，应固定至S_1甚至骨盆，腰部柔韧性和代偿能力完全丢失，且矫形后骨盆失代偿可以加重躯干偏斜，因此，术中并未完全融合腰弯，术后嘱患者穿戴鞋垫以纠正骨盆倾斜，术后复查影像学显示腰弯通过部分代偿矫形效果满意，且躯干未出现严重偏斜。

综上所述，采用一期手术治疗脊柱侧弯合并椎管内病变安全、有效，通过截骨矫形术可以获得良好效果，术后神经功能改善，未出现手术相关并发症。但是由于本研究样本量较小且为回顾性研究，具有一定局限性。此外，矫形丢失和骨盆代偿情况尚待长期随访观察。一期手术治疗脊柱侧弯合并椎管内病变应具备以下条件：(1)手术团队具有同时处理椎管内病变和脊柱侧弯的经验。(2)术前制定详细的手术计划。(3)术中行神经电生理学监测。

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