

临床论著

后路半椎体切除矫形内固定术治疗颈胸段
半椎体畸形的疗效分析

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【摘要】目的:评估一期后路半椎体切除矫形内固定术治疗颈胸段半椎体畸形的疗效。**方法:**回顾性分析 2010 年 6 月~2017 年 4 月在我院行一期后路半椎体切除矫形内固定手术且满足入选标准的 32 例颈胸段半椎体畸形患者,男 15 例,女 17 例,年龄 5~18 岁(10.1 ± 4.2 岁)。单个半椎体 25 例,2 个半椎体 7 例;C7 1 例,T1 5 例,T2 12 例,T3 10 例,T4 11 例。术前均有不同程度的肩部不平衡和颈部倾斜。在术前、术后和末次随访时的站立位全脊柱 X 线片上测量局部侧凸角、锁骨角、T1 倾斜角、颈部倾斜、头部偏斜以及局部后凸角等参数,采用配对 t 检验进行比较分析。**结果:**32 例患者均完成矫形手术,手术时间 $175\sim 275\text{min}$ ($223.8\pm 41.6\text{min}$),出血量 $310\sim 470\text{ml}$ ($342.3\pm 45.9\text{ml}$)。术中胸膜撕裂 1 例,术后出现 Horner 综合征 1 例,上肢神经根性疼痛 2 例,经保守治疗后均恢复。共置入 261 枚椎弓根螺钉,55 枚穿破椎弓根皮质,但均未侵犯脊髓及周围脏器和血管,未行翻修手术。术后随访 12~48 个月(19.3 ± 10.5 个月),局部侧凸角由术前 $41.1^\circ\pm 12.3^\circ$ 矫正到术后 $17.5^\circ\pm 6.7^\circ$ ($P<0.001$),末次随访时为 $20.1^\circ\pm 5.8^\circ$,与术后比较无显著性差异 ($P=0.102$);局部后凸角由术前 $21.5^\circ\pm 9.1^\circ$ 矫正到术后 $16.8^\circ\pm 6.3^\circ$ ($P<0.05$),末次随访时为 $17.5^\circ\pm 4.9^\circ$ ($P=0.622$);远端代偿弯由术前 $16.9^\circ\pm 5.3^\circ$ 减少到术后 $12.2^\circ\pm 5.5^\circ$ ($P<0.001$),末次随访时为 $15.5^\circ\pm 7.7^\circ$ ($P=0.053$)。T1 倾斜角、锁骨角、颈部倾斜以及头部偏斜在术后均较术前得到显著性改善 ($P<0.05$),末次随访时影像学观察指标进一步改善 ($P<0.05$)。**结论:**颈胸段半椎体畸形患者行一期后路半椎体切除矫形内固定术手术时间短、创伤小,可有效矫正侧凸畸形,获得满意的治疗效果。

【关键词】半椎体畸形;半椎体切除术;颈胸段;矫形效果

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【Abstract】 Objectives: To evaluate the radiographic outcomes of one-stage posterior hemivertebra resection in the treatment of cervicothoracic hemivertebra deformity. **Methods:** From June 2010 to April 2017, 32 cases with cervicothoracic hemivertebra deformity who were managed by one-stage posterior hemivertebra resection and met the inclusion criteria were reviewed. There were 15 boys and 17 girls with a mean age of 10.1 ± 4.2 years (range, 5-18 years). There were 25 cases with one hemivertebra and 7 cases with two hemivertebrae. The hemivertebra located in C7 in 1 patient, T1 in 5 patients, T2 in 12 patients, T3 in 10 patients and T4 in 11 patients. Before surgery, all patients had torticollis and shoulder imbalance. The following radiographic parameters were measured: local scoliosis, local kyphosis, shoulder balance, neck tilt, head shift, and sagittal parameters. The paired Student's t test was used to analyze the data. **Results:** The operation time was $175\sim 275$ minutes ($223.8\pm 41.6\text{min}$), the blood loss was $310\sim 470\text{ml}$ ($342.3\pm 45.9\text{ml}$). There were one case with Horner syndrome, two cases with transient radicular pain of arm after surgery, and one case with pleural tear during surgery, all these patients recovered after conservation treatment. A total of 261 pedicle screws was placed. The incidence of pedicle screw malposition was 7.3% without any neurovascular injury. The mean follow-up

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period was 19.3 ± 10.5 months. Local scoliosis was significantly corrected from $41.1^\circ \pm 12.3^\circ$ preoperatively to $17.5^\circ \pm 6.7^\circ$ postoperatively ($P < 0.001$) and $20.1^\circ \pm 5.8^\circ$ at last follow-up with no significant correction loss ($P = 0.102$). Local kyphosis was significantly corrected from $21.5^\circ \pm 9.1^\circ$ preoperatively to $16.8^\circ \pm 6.3^\circ$ postoperatively ($P < 0.05$) and $17.5^\circ \pm 4.9^\circ$ at last follow-up with no significant correction loss ($P = 0.102$). The distal compensatory curve was corrected from $16.9^\circ \pm 5.3^\circ$ preoperatively to $12.2^\circ \pm 5.5^\circ$ postoperatively ($P < 0.001$), which slightly increased to $15.5^\circ \pm 7.7^\circ$ at last follow-up ($P = 0.053$). T1 tilt, clavicle angle, neck tilt and head shift were significantly improved at postoperation and no significant correction loss was found during follow-up. **Conclusions:** For patients with cervicothoracic hemivertebra deformity, one-stage posterior hemivertebra resection with instrumentation has shorter operation time, less operation wound and optimistic deformity correction.

【Key words】 Hemivertebra deformity; Hemivertebra resection; Cervicothoracic hemivertebra; Correction outcomes

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半椎体畸形是先天性脊柱侧凸最常见的原因,可见于颈胸段、胸椎及腰椎^[1]。颈胸段半椎体畸形是指位于 C6~T4 的半椎体畸形^[2-5]。相比胸腰椎半椎体畸形,颈胸段半椎体畸形虽然发病率相对较低^[3,4],但常引起明显的肩颈部畸形(包括肩部不平衡、颈部倾斜、头部倾斜等),严重者可引起面部发育不对称,影响患者美观及心理健康^[6]。一期后路半椎体切除矫形内固定术被认为是颈胸段半椎体畸形最为有效的治疗策略之一^[6-8],但有关颈胸段半椎体畸形行半椎体切除手术疗效的报道目前仍较少。本研究回顾性分析在我院行一期后路半椎体切除矫形内固定手术的先天性颈胸段半椎体畸形患者的影像学资料,评估一期后路半椎体切除内固定治疗先天性颈胸段半椎体畸形的疗效。

1 资料与方法

1.1 一般资料

回顾性分析 2010 年 6 月~2017 年 4 月在我院行半椎体切除手术的先天性脊柱侧凸畸形患者的临床及影像学资料,入选标准:(1)半椎体位于颈胸段(C6~T4 椎体之间)且不伴有分节不良;(2)行单一后路半椎体切除矫形内固定手术;(3)术后随访满 12 个月。排除标准:(1)既往有脊柱手术史;(2)合并高肩胛症等。

共有 32 例患者纳入本研究,其中男 15 例,女 17 例,年龄 5~18 岁(10.1 ± 4.2 岁)。单个半椎体患者 25 例,2 个半椎体患者 7 例;C7 1 例 (2.6%), T1 5 例 (12.8%), T2 12 例 (30.8%), T3 10 例 (25.6%), T4 11 例 (28.2%)。术前所有患者外观上

均有不同程度的肩部不平衡和颈部倾斜,12 例患者面部发育不对称;2 例出现神经功能损害症状, Frankel 分级均为 C 级。全脊柱 MRI 示 2 例患者伴脊髓拴系,1 例患者伴脊髓纵裂,1 例合并 Chiari 畸形。

1.2 手术方法

患者全身麻醉后取俯卧位,逐层切开、骨膜下剥离显露半椎体及拟固定节段的棘突和椎板,在半椎体上下椎体置入椎弓根螺钉,10 例患者术中应用 O-arm 三维导航技术辅助下置钉。椎体椎弓根细小椎弓根螺钉置入困难者用椎板钩替代。随后切除半椎体后份结构,包括椎板、关节突、横突以及部分椎弓根。沿椎弓根基底剥离,保护神经根及血管,向外前方剥离,尽量显露半椎体外侧,向内剥离保护脊髓直至将完整半椎体暴露在视野。位于胸椎的半椎体同时切除对应肋骨头,术中操作仔细,避免误伤胸膜。对于存在 2 个半椎体的患者,选择引起畸形的半椎体进行切除。在切除半椎体前先用一临时棒置于凹侧以稳定脊柱,随后将半椎体从凸侧切除并刮除残留的半椎体骨质,切除半椎体上下侧椎间盘和软骨终板。切除半椎体时注意避免损伤椎体侧前方血管和胸膜组织、腹侧的交感神经链和食管以及内侧的脊髓等。将一预弯的短棒置于凸侧,逐步对凸侧棒进行抱紧加压直至截骨间隙闭合后将两侧棒与螺钉加压锁紧直至截骨面上下椎体骨面与骨面紧密闭合。将脊柱后份进行去皮质处理提供合适的植骨床,用切除的半椎体及椎板骨质进行自体骨植骨。手术操作过程均在脊髓体感诱发电位 (SSEP) 及运动诱发电位 (MEP) 监测下进行。术后佩戴颈胸段保护

性支具 3 个月。

1.3 影像学评估

术前、术后及末次随访时拍摄站立位全脊柱正侧位 X 线片,对局部冠状面侧凸角、远端代偿弯以及矢状面的局部后凸角、胸椎后凸角、腰椎前凸角进行测量,同时测量以下四个影像学指标以评估患者颈肩部畸形情况:(1)T1 倾斜角,T1 椎体上终板与水平线之间夹角(若半椎体位于 T1,则以 C7 椎体下终板与水平线之间夹角代替);(2)锁骨角,两侧锁骨最高切点连线与水平线之间夹角;(3)颈部倾斜,冠状面上颈椎纵轴(C2 和 C7 椎体中心连线)与竖直纵轴的夹角;(4)头部偏斜,冠状面上上下颌骨中点到骶骨正中线的垂直距离(图 1)。

1.4 统计学处理

数据采用 SPSS 18.0 统计软件进行统计学处理。数据以均值±标准差表示,术前、术后及末次随访时测量结果对比采用配对 *t* 检验。以 $P<0.05$ 为差异有统计学意义。

2 结果

32 例患者均完成半椎体切除矫形内固定术,手术时间 175~275min(223.8 ± 41.6 min),术中出血量为 310~470ml(342.3 ± 45.9 ml),固定节段 5.8 ± 0.9 个。1 例患者在切除 T1 和 T4 半椎体后出现了 Horner 综合征,术后 3 个月随访时恢复。2 例患者术后出现半椎体同侧上肢神经根性疼痛,经过保守治疗后分别在术后 1 周及 2 周后症状明显改善。1 例患者在切除 T4 半椎体时发生胸膜破裂,术后 CT 示中量胸腔积液,患者无明显胸闷、气短

等不适症状,予以保守治疗,未置胸腔引流管,术后 1 年随访胸腔积液完全吸收。

本组共置入椎弓根螺钉 261 枚(其中 10 例患者在 O-arm 三维导航技术辅助下置钉),椎板钩 28 枚,其中 55 枚(21%)椎弓根螺钉不同程度突破椎弓根皮质,术后 CT 检查所有位置不良的螺钉均未侵犯脊髓以及周边脏器及血管,未行翻修手术。

32 例患者随访 12~48 个月(19.3 ± 10.5 个月),术前、术后和末次随访时的局部侧凸角、胸椎后凸角、腰椎前凸角、局部后凸角、远端代偿弯、T1 倾斜角、锁骨角、颈部倾斜以及头部偏斜见表 1。局部侧凸角由术前 $41.1\pm12.3^\circ$ 矫正到术后的 $17.5\pm6.7^\circ$ ($P<0.001$),矫正率为 $(55.1\pm9.3)\%$,末次随访时为 $20.1\pm5.8^\circ$,与术后比较无统计学差异($P=0.102$)。局部后凸角由术前 $21.5\pm9.1^\circ$ 矫正到术后的 $16.8\pm6.3^\circ$ ($P<0.05$),末次随访无明显矫正丢失($P=0.622$)。远端代偿弯由术前的 $16.9\pm5.3^\circ$ 减少到术后的 $12.2\pm5.5^\circ$ ($P<0.001$),末次随访时较术后有所增加,但无统计学差异($12.2\pm5.5^\circ$ vs $15.5\pm7.7^\circ$, $P=0.053$)。T1 倾斜角、锁骨角、颈部倾斜以及头部偏斜在术后均较术前得到明显改善($P<0.05$),末次随访时较术后进一步得到了改善($P<0.05$,图 2)。

术前 2 例下肢不全瘫患者分别在术后 6 个月和 9 个月随访时下肢肌力恢复正常, Frankel 分级 E 级。术后及随访过程中未发生感染、假关节形成、内固定失败、交界性后凸等并发症,5 例远端代偿弯较术后进展 $>20^\circ$,予以支具治疗后侧凸进展得到明显控制,无患者行翻修手术。

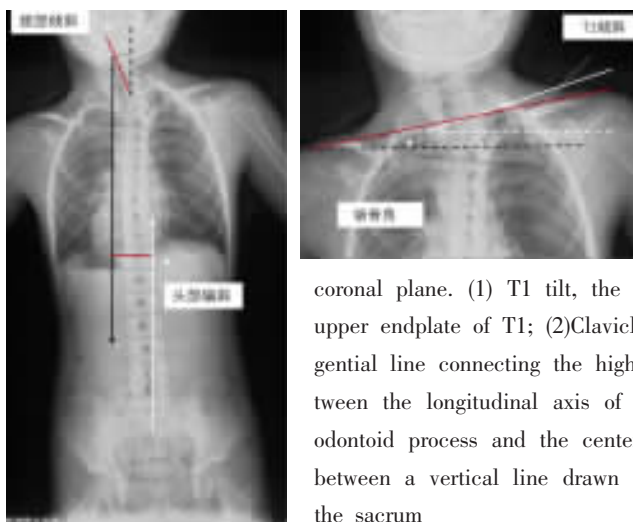


图 1 冠状面上测量 T1 倾斜、锁骨角、颈部倾斜、头部偏斜测量方法:(1)T1 倾斜角,T1 椎体上终板与水平线之间夹角;(2)锁骨角,两侧锁骨最高切点连线与水平线之间夹角;(3)颈部倾斜,冠状面上颈椎纵轴(C2 和 C7 椎体中心连线)与竖直纵轴的夹角;(4)头部偏斜,冠状面上上下颌骨中点到骶骨正中线的垂直距离

Figure 1 Illustrations of the parameters measured on coronal plane. (1) T1 tilt, the angle between the horizontal line and the line through the upper endplate of T1; (2) Clavicle angle, the angle between the horizontal line and the tangential line connecting the highest two points of each clavicle; (3) Neck tilt, the angle between the longitudinal axis of the cervical spine (the line drawn from center of the C2 odontoid process and the center of C7) and the vertical line; (4) Head shift, the distance between a vertical line drawn from the middle of the mandibular body to the middle of the sacrum

表 1 术前、术后以及末次随访时的影像学及美学指标

($\bar{x} \pm s, n=32$)

Table 1 Radiologic and cosmetic parameters measured before and after surgery, and at the final follow-up

	术前 Preoperation	术后 Postoperation	矫正率(%) Correction rate	末次随访 Final follow-up
局部侧凸角 Local scoliosis(°)	41.1±12.3	17.5±6.7 ^①	55.1±9.3	20.1±5.8 ^①
T1 倾斜角 T1 tilt(°)	18.8±6.3	10.1±4.5 ^①	48.9±19.1	7.3±4.1 ^{①②}
锁骨角 Clavicle angle(°)	15.2±7.1	9.8±6.9 ^①	37.2±10.3	6.2±5.1 ^{①②}
颈部倾斜 Neck tilt(°)	22.1±8.3	12.4±7.3 ^①	44.3±12.6	8.8±7.0 ^{①②}
头部偏斜 Head shift(mm)	23.3±10.5	16.8±9.3 ^①	30.1±12.8	8.4±6.8 ^{①②}
远端代偿弯 Distal compensatory curve(°)	16.9±5.3	12.2±5.5 ^①	29.3±10.3	15.5±7.7 ^①
局部后凸角 Segmental kyphosis(°)	21.5±9.1	16.8±6.3 ^①	21.8±8.2	17.5±4.9
胸椎后凸角 Thoracic kyphosis(°)	26.6±10.5	25.8±10.1	3.6±6.7	26.1±9.6
腰椎前凸角 Lumbar lordosis(°)	33.8±12.1	33.6±11.9	1.9±3.2	34.4±11.5

注:①与术前比较 $P<0.05$;②与术后比较 $P<0.05$ Note: ①Compared with preoperation, $P<0.05$; ②Compared with postoperation, $P<0.05$

3 讨论

3.1 颈胸段半椎体畸形特征

关于颈胸段半椎体畸形的发病率及自然史文献中目前尚无确切的数据报道。通常颈胸段半椎体在畸形角度较小或畸形进展缓慢时,即可出现明显的外观畸形^[4],包括原发的肩颈部畸形(如肩部不平衡和颈部倾斜)和继发的外观畸形(如斜颈、头部倾斜或面部发育不对称等)^[9,10]。对出现明显的肩部失平衡、颈部倾斜或躯干倾斜患者,手术常为最有效的治疗方法^[9]。本组患者平均年龄为 10.1 岁,术前均出现了不同程度的肩部不平衡和颈部倾斜,其中 12 例(37.5%)患者伴有面部发育不对称。部分颈胸段半椎体患者可伴发其他骨骼畸形,如上胸段肋骨缺如、高肩胛症等;也可伴发脊髓发育性畸形,如脊髓空洞症、脊髓裂或脊髓脊膜膨出等^[4]。本组患者中,有 2 例术前伴脊髓拴系,1 例伴有脊髓纵裂,还有 1 例合并有 Chiari 畸形。更重要的是,部分此类患者可合并神经损害表现,严重者可出现四肢不完全瘫甚至完全瘫等^[4]。本组 2 例患者术前即已出现神经功能损害,均因半椎体向后方突入椎管引起脊髓受压所致。颈胸段半椎体的手术治疗适应证主要包括严重的结构性侧后凸、侧后凸畸形进展迅速或预后不良者。此外,笔者认为颈胸段半椎体如引起明显的肩部失平衡、颈部倾斜或躯干倾斜、代偿弯出现且进展者,同样也需积极行手术治疗。

3.2 手术策略及疗效评估

颈胸段半椎体引起的脊柱侧后凸畸形较为僵硬,且属于应力集中区域,因此对于内固定要求较

高,较少采用短节段固定^[11]。为达到足够的术后稳定性并减少术后内固定相关并发症的发生率,固定节段至少应为半椎体上下各 2 个节段。本组患者平均固定节段为 5.8 个,侧凸矫正率约为 55.1%,术后矫形效果满意,随访时均未见内固定断裂及明显矫正丢失。

对于颈胸段半椎体畸形患者,能否改善患者的头颈部倾斜以及双肩失平衡状态是评价颈胸段半椎体切除内固定手术疗效的重要指标^[5]。文献中报道肩平衡与许多参数有关,其中 T1 倾斜角与内肩失平衡有较强相关性,而锁骨角与外肩失平衡有较强相关性^[12-14]。本研究中 T1 倾斜角术前平均为 18.8°,术后改善为 10.1°,锁骨角术前为 15.2°,术后改善为 9.8°,该结果表明术后患者内外肩平衡均得到了明显改善,患者术后站立时外观畸形的改善进一步证明了本研究结论。此外,本组患者在末次随访时头部偏斜也由术前的 23.3mm 自发纠正至 8.4mm。因此,对于颈胸段半椎体患者,为取得较好矫形效果,手术过程中应尽量恢复 T1 水平化及改善锁骨角。

3.3 手术并发症及预防

由于颈胸段半椎体畸形患者同时常伴有神经和血管的发育畸形,并且此区域椎弓根常较为细小。因此,手术暴露或者截骨以及置钉过程中造成神经、血管损伤的风险较大^[4,15-17]。本组患者中 1 例在术后出现了 Horner 综合征,其可能原因是切除半椎体过程中对交感神经节造成了损伤。另有 2 例患者在术后出现一过性上肢神经根性疼痛,其原因可能是术中矫形过程中对神经根造成牵拉

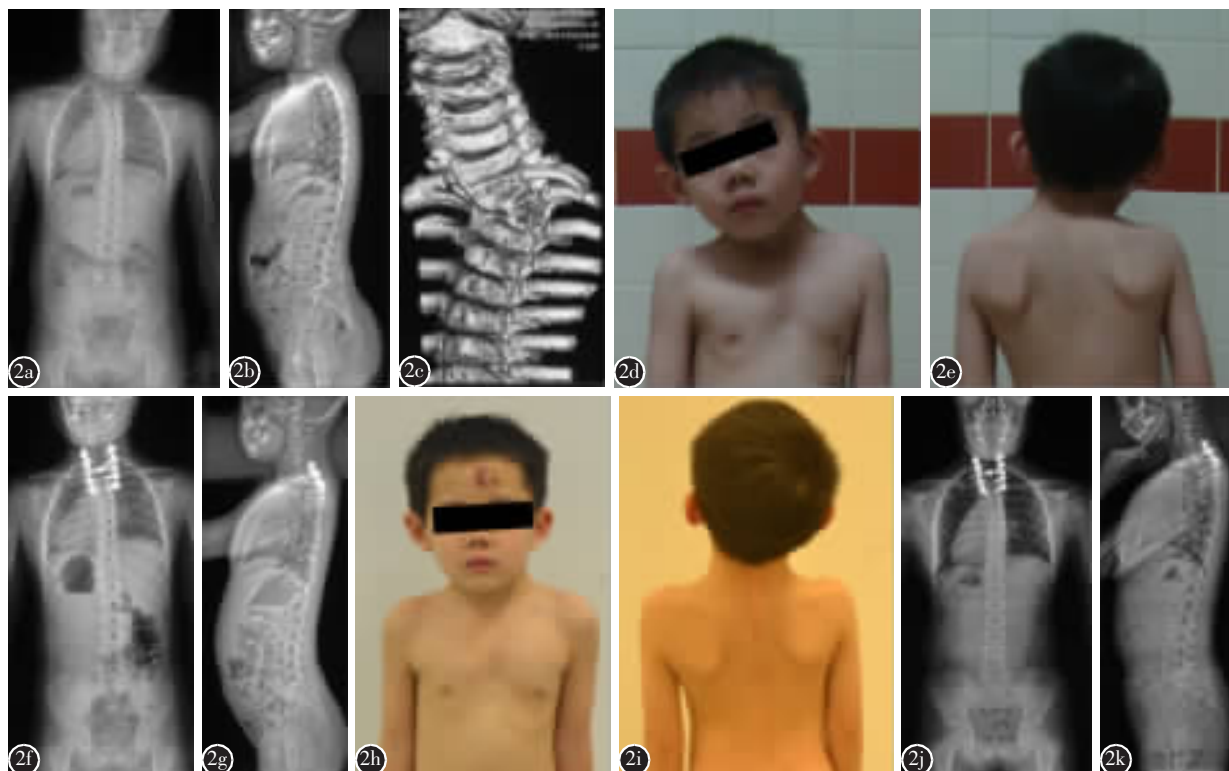


图 2 患者女, 5 岁, 先天性半椎体畸形 **a, b** 术前正侧位 X 线片示冠状面上颈部倾斜角为 26° , T1 倾斜角为 19° , 锁骨角为 14° , 局部侧凸角为 35° , 远端代偿弯 19° , 头部偏斜为 23mm; 矢状面上局部后凸角为 16° , 胸椎后凸角为 26° , 腰椎前凸角为 32° **c** 术前 CT 三维重建示 T3 半椎体畸形 **d, e** 术前外观照示颈部倾斜、头部偏斜明显 **f, g** 后路 T3 半椎体切除矫形内固定术后 X 线片示颈部倾斜角为 12° , T1 倾斜角为 9° , 锁骨角为 6° , 局部侧凸角为 15° , 远端代偿弯为 12° , 头部偏斜为 18mm **h, i** 术后 3 个月外观照示颈部倾斜、头部偏斜明显改善, 双肩平衡恢复 **j, k** 术后 48 个月随访 X 线片示颈部倾斜角为 8° , T1 倾斜角为 7° , 锁骨角为 3° , 局部侧凸角为 12° , 远端代偿弯为 8° , 头部偏斜为 7mm

Figure 2 A 5 years old girl with congenital hemivertebra deformity **a, b** X-ray films showed the neck tilt, T1 tilt, clavicle angle, local scoliosis, distal compensatory curve and neck shift were 26° , 19° , 14° , 35° , 19° and 23mm on the coronal plane respectively; and the local kyphosis, thoracic kyphosis and lumbar lordosis were 16° , 26° and 32° on the sagittal plane respectively **c** Preoperative CT reconstruction shows a T3 hemivertebra **d, e** Preoperative photos showed her neck tilted and head shift aside **f, g** She underwent T3 hemivertebra resection and fusion. The neck tilt, T1 tilt, clavicle angle, local scoliosis, distal compensatory curve and neck shift were corrected to 12° , 9° , 6° , 15° , 12° and 18mm respectively after surgery **h, i** At 3-month follow-up, her shoulder imbalance and head shift were significantly improved **j, k** The neck tilt, T1 tilt, clavicle angle, local scoliosis, distal compensatory curve and neck shift was further improved to 8° , 7° , 3° , 12° , 8° and 7mm respectively at 48-month follow-up

引起。1 例胸膜破裂的患者, 主要是由于术中操作不慎引起。另外, 由于颈胸段椎弓根较为纤细, 因此术后最常见的并发症为螺钉位置不良。Privitera 等^[18]报道 T1、T2 椎体不良置钉的发生率分别为 28.6% 和 18.2%, 远高于其他节段椎体。因此, 对于颈胸段半椎体患者, 术前 CT 如发现椎弓根发育不良以及过于纤细, 在保持内固定稳定的同时可考虑使用椎板钩代替椎弓根螺钉以降低不良置钉的风险。此外, 术中 O-arm 三维导航技术的应用

也可提高复杂置钉的安全性^[19]。本组患者中, 共有 8 例患者使用了椎板钩(28 枚), 10 例患者应用了 O-arm 三维导航技术辅助置钉, 椎弓根螺钉置钉不良的发生率仅为 7.3%。因此, 对于颈胸段半椎体患者, 术前 CT 平扫及三维重建以及必要时行颈椎动脉 CT 造影以及术中 O-arm 导航技术的应用对于提高手术的安全性都有一定意义。

综上, 对于颈胸段半椎体所致的先天性脊柱侧凸患者, 单一后路半椎体切除手术时间短、创伤

小、术后局部侧凸角、T1 倾斜角、锁骨角、颈部倾斜以及头部偏斜参数均获得良好改善,并且畸形矫正在随访中得到良好的维持,获得了满意的疗效。然而,本组患者大部分为儿童患者,其脊柱仍有生长潜能,术后随访时间较短,远期疗效仍需进一步随访观察。

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