

弯角椎体成形术治疗胸腰椎骨质疏松性椎体压缩骨折的疗效分析

林玉江, 林 茜, 杨利民, 杨 健

(青岛市市立医院东院脊柱外科 266011 山东省青岛市)

【摘要】目的:评估分析弯角椎体成形术(percutaneous curved vertebroplasty, PCVP)治疗胸腰椎骨质疏松性椎体压缩骨折的临床疗效。**方法:**选取 96 例胸腰椎骨质疏松性椎体压缩骨折患者,共 128 节病椎,将其分为弯角组(36 例,43 节)、单侧组(32 例,42 节)及双侧组(28 例,43 节),分别行 PCVP 及单侧、双侧椎弓根入路椎体成形术。3 组患者的性别、年龄、骨密度及病椎节段分布均无统计学差异($P>0.05$)。统计 3 组手术时间、X 线曝光次数、骨水泥注入量及术前、术后 24h、术后 3 个月疼痛视觉模拟评分(VAS 评分),术后复查 CT 评价骨水泥渗漏率,进行统计学分析。**结果:**弯角组与单侧组的手术时间、X 线曝光次数均明显少于双侧组,差异有统计学意义($P<0.05$),弯角组和单侧组无显著性差异($P>0.05$)。弯角组、单侧组、双侧组的骨水泥注入量比较,双侧组最多($6.2\pm 1.5\text{ml}$),弯角组次之($4.5\pm 1.3\text{ml}$),单侧组最少($3.4\pm 1.2\text{ml}$),组间两两比较差异有统计学意义($P<0.05$)。弯角组、单侧组、双侧组的骨水泥渗漏率比较,单侧组(28.6%, 12/42)最高,双侧组(18.6%, 8/43)次之,弯角组(9.3%, 4/43)最低,组间两两比较差异有统计学意义($P<0.05$)。3 组患者术后疼痛均明显缓解,术后 24h 及术后 3 个月 VAS 评分均明显低于术前($P<0.05$),术后 24h 及术后 3 个月 VAS 评分比较无显著性差异($P>0.05$),同时间点组间比较亦无显著性差异($P>0.05$)。**结论:**PCVP 具有操作简单、手术时间短、X 线透视次数少、创伤小、并发症少等优势,是治疗胸腰椎骨质疏松性椎体压缩骨折的有效微创手术方法。

【关键词】胸腰椎压缩性骨折;弯角椎体成形术;骨质疏松;微创

doi:10.3969/j.issn.1004-406X.2017.05.07

中图分类号:R683.2, R687.3 文献标识码:A 文章编号:1004-406X(2017)-05-0423-06

Effect of percutaneous curved vertebroplasty in the treatment of osteoporotic thoracolumbar vertebral compressive fractures/LIN Yujiang, LIN Qian, YANG Limin, et al/Chinese Journal of Spine and Spinal Cord, 2017, 27(5): 423-428

【Abstract】Objectives: To investigate the clinical value of percutaneous curved vertebroplasty(PCVP) in the treatment of osteoporotic thoracolumbar vertebral compressive fractures. **Methods:** 96 patients(128 vertebrae) suffering from osteoporotic thoracolumbar vertebral compressive fractures were divided into three groups: curved group(36 patients, 43 vertebrae), unilateral group(32 patients, 42 vertebrae) and bilateral group(28 patients, 43 vertebrae). There was no significant difference among the three groups in gender, age, bone mineral density and diseased vertebral segment($P>0.05$). The average operation time, X-ray exposure, bone cement injection volume, bone cement leakage rate were recored and compared. The VAS scores were compared at preoperation, 24 hours and 3 months after operation. **Results:** The operation time of curved group and unilateral group were less than that of bilateral group, the differences were statistically significant($P<0.05$). But there was no statistical difference between curved group and unilateral group ($P>0.05$). The X-ray exposure of curved group and unilateral group were less than that of bilateral group, the differences were statistically significant ($P<0.05$). But there was no statistical difference between curved group and unilateral group ($P>0.05$). As for the bone cement injection volume, bilateral group($6.2\pm 1.5\text{ml}$) had the highest volume and following was curved group($4.5\pm 1.3\text{ml}$), and the least was unilateral group($3.4\pm 1.2\text{ml}$), the differences were statistically significant among the three groups($P<0.05$). As for the bone cement leakage rate, unilateral group(28.6%, 12/42) was the

第一作者简介:男(1982-),医学硕士,主治医师,研究方向:脊柱外科

电话:(0532)88905495 E-mail:404703605@qq.com

通讯作者:杨利民 E-mail:932021474@qq.com

most and following was bilateral group(18.6%, 8/43), and the least was curved group(9.3%, 4/43), the differences were statistically significant among the three groups ($P<0.05$). All the patients in the three groups obtained obvious pain relief. The average VAS score at 24 hours and 3 months after operation was lower than that at preoperation ($P<0.05$). But there was no statistical difference in the average VAS score between 24 hours and 3 months after operation($P>0.05$), and there were no statistical differences among the three groups ($P>0.05$). **Conclusions:** Percutaneous curved vertebroplasty has the advantage of easy operation, shorter operation time, less X-ray exposure, less trauma and complications, which is a minimal invasive method for osteoporotic thoracolumbar vertebral fractures.

[Key words] Thoracolumbar vertebral fractures; Percutaneous curved vertebroplasty; Osteoporosis; Minimal invasive

[Author's address] Department of Spine Surgery, Qingdao Municipal Hospital, Qingdao, Shandong, 266011, China

骨质疏松性椎体压缩骨折 (osteoporotic vertebral compressive fractures, OVCF) 是老年人的一种常见疾病, 经皮穿刺椎体成形术 (percutaneous vertebroplasty, PVP) 因具有创伤小、疗效好、并发症少、安全性高等优势, 被广泛用于 OVCF 的治疗。PVP 手术的疗效与骨水泥弥散情况相关, 单侧入路会造成骨水泥仅在椎体一侧弥漫填充。为使骨水泥在椎体内弥漫均匀, 就需要单侧加大穿刺内倾角度或者行双侧穿刺, 然而这就意味着穿透椎弓根内壁、骨水泥外溢以及脊髓神经损伤的风险增加^[1]。我院自 2016 年 1 月起, 采用弯角椎体成形术 (percutaneous curved vertebroplasty, PCVP) 治疗 OVCF, 同时与单侧及双侧入路 PVP 手术进行对比分析, 评估其临床疗效。

1 资料与方法

1.1 一般资料

纳入标准: (1) 骨密度检测符合骨质疏松诊断标准; (2) 无明显脊髓和神经根受压症状和体征; (3) 椎体后壁完整, 无椎弓根骨折; (4) 无转移肿瘤、血管瘤等病理性骨折; (5) 影像学检查明确诊断为椎体新鲜压缩性骨折; (6) 随访资料完整。

2016 年 1 月~2016 年 9 月因胸腰椎 OVCF 入院手术并符合上述标准的患者 96 例, 其中男 20 例, 女 76 例, 年龄 60~86 岁 (71.5±10.6 岁); 共 128 节病椎, 分布于 T8~L5; 术前检测骨密度 T 值为 -3.2 ± 0.6 ($-2.5\sim-4.2$)。将 96 例患者按照入院时间随机分为 3 组, 1~3 月入院患者行 PCVP 手术, 分入弯角组; 4~6 月入院患者行单侧入路 PVP 手术, 分入单侧组; 7~9 月入院患者行双侧入路 PVP 手术, 分入双侧组。3 组患者的性别、年龄、骨密度及病椎节段分布见表 1, 组间比较差异均无统计学意义 ($P>0.05$)。

1.2 手术方法

1.2.1 弯角组 患者俯卧位, C 型臂 X 线机透视定位病变椎体, 定位体表标志, 确定进针点, 用 1% 利多卡因局部麻醉, 透视下利用直向穿刺针经单侧椎弓根穿刺直至病椎椎体后缘前约 5mm 处, 正位透视确认入针点位于椎弓根影的外上象限且未突破椎弓根内壁, 侧位透视调节穿刺针的深度和方向, 拔出穿刺针芯, 经穿刺针外套管置入弯角注入器 (图 1), 正位透视下弯角注入器尖端越过病椎椎体中线, 侧位透视下达到椎体前中 1/3 处, 准备骨水泥 (聚甲基丙烯酸甲酯, polymethyl-

表 1 弯角组、单侧组及双侧组患者的一般资料对比

Table 1 Comparison of the general data of the curved, unilateral and bilateral groups

	例数 <i>n</i>	男/女 Male/ female	年龄 (岁) Age(year)	骨密度 Bone density	病椎分布 (节) Vertebral distribution(vertebra)									
					T8	T9	T10	T11	T12	L1	L2	L3	L4	L5
弯角组 Curved group	36	8/28	72.5±10.2	-3.1±0.6	1	1	2	8	10	8	4	3	2	4
单侧组 Unilateral group	32	6/26	69.2±12.6	-3.3±0.8	0	1	0	9	12	10	2	2	2	4
双侧组 Bilateral group	28	6/22	70.1±11.8	-2.9±0.4	0	0	1	8	11	14	4	2	1	2

methacrylate, PMMA), 于骨水泥拔丝期时, 在退弯角注入器时行多点注射, 填充骨折椎体, C 型臂 X 线机全程透视下观察骨水泥弥散情况, 当其充盈接近椎体后壁时, 立即停止注入, 待骨水泥稍硬化后, 拔出穿刺套管针(图 2)。

1.2.2 单侧组 经皮穿刺置入穿刺套管针步骤同弯角组, 拔出穿刺针芯, 经穿刺针外套管置入实心钻, 侧位透视下达到椎体前中 1/3 处, 准备骨水

泥, 于骨水泥拔丝期时, 缓慢推注, C 型臂 X 线机全程透视下观察骨水泥弥散情况, 当其充盈接近椎体后壁时, 立即停止注入。待骨水泥稍硬化后, 先旋转穿刺针再拔出, 以便分离管腔内与椎体内的骨水泥, 防骨水泥拖尾现象。

1.2.3 双侧组 手术方式基本同单侧组, 经双侧椎弓根穿刺注入骨水泥

3 组患者术后平卧, 观察生命体征及双下肢

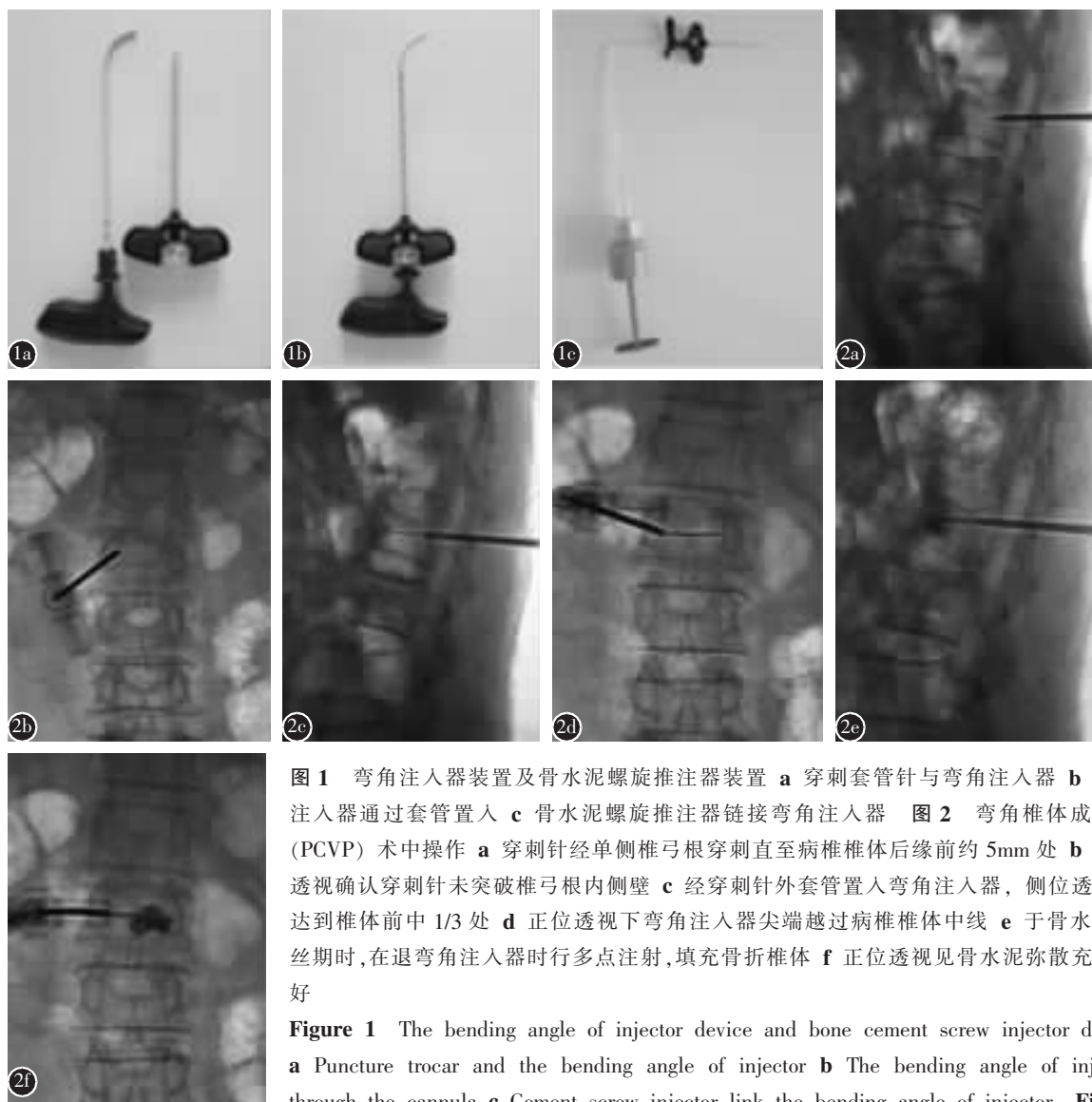


图 1 弯角注入器装置及骨水泥螺旋推注器装置 **a** 穿刺套管针与弯角注入器 **b** 弯角注入器通过套管置入 **c** 骨水泥螺旋推注器链接弯角注入器 **图 2** 弯角椎体成形术 (PCVP) 术中操作 **a** 穿刺针经单侧椎弓根穿刺直至病椎椎体后缘前约 5mm 处 **b** 正位透视确认穿刺针未突破椎弓根内侧壁 **c** 经穿刺针外套管置入弯角注入器, 侧位透视下达到椎体前中 1/3 处 **d** 正位透视下弯角注入器尖端越过病椎椎体中线 **e** 于骨水泥拔丝期时, 在退弯角注入器时行多点注射, 填充骨折椎体 **f** 正位透视见骨水泥弥散充盈良好

Figure 1 The bending angle of injector device and bone cement screw injector device **a** Puncture trocar and the bending angle of injector **b** The bending angle of injector through the cannula **c** Cement screw injector link the bending angle of injector **Figure 2** Intraoperative fluoroscopy imaging data of percutaneous curved vertebroplasty (PCVP)

2 Intraoperative fluoroscopy imaging data of percutaneous curved vertebroplasty (PCVP) **a** The puncture needle was punctured by a single pedicle of vertebral arch until the posterior edge of the vertebral body was about 5mm **b** Antero-posterior X-ray confirmed that the puncture needle did not break through the medial wall of the pedicle of vertebral arch **c** The bending angle of injector was put in through the cannula; lateral perspective to reach the anterior 1/3 **d** Anteroposterior X-ray fluoroscopy, the bending angle of injector tip across the vertebral midline **e** During bone cement drawing, multi-point injection were done to fill fractured vertebrae when the bending angle of injector was back **f** Anteroposterior X-ray fluoroscopy, the bone cement diffused well

感觉运动情况,术后 6h 佩戴腰围等支具可下地活动。

1.3 观察指标

统计 3 组的手术时间、X 线曝光次数、骨水泥注入量及术前、术后 24h、术后 3 个月的疼痛视觉模拟评分(visual analogue scale/score, VAS),术后复查 CT 评价骨水泥渗漏率。

1.4 统计学分析

所得数据均采用 SPSS 17.0 进行统计学处理分析,计量资料用均数 $\pm$ 标准差($\bar{x}\pm s$)表示,采用配对 t 检验, $P<0.05$ 为差异有统计学意义。

2 结果

3 组患者手术均顺利完成,术中、术后无骨水泥栓塞和血压下降等不良反应、心脑血管事件、硬膜外血肿、脊髓和神经根损伤及肺栓塞等并发症发生,有 24 节椎体发生骨水泥外溢,渗漏部位多位于椎间盘、椎体前方及侧方。术后 CT 发现有 6 节椎体出现少量椎管内骨水泥渗漏,但无明显神经症状。随访 3 个月,3 组患者均无相邻椎体骨折(图 3)。

3 组患者的手术时间、X 线曝光次数、骨水泥注入量、骨水泥渗漏率及术前、术后 24h、术后 3 个月 VAS 评分见表 2。弯角组与单侧组手术时间

明显少于双侧组,差异有统计学意义($P<0.05$),弯角组和单侧组手术时间无统计学差异($P>0.05$)。弯角组与单侧组 X 线曝光次数明显少于双侧组,差异有统计学意义($P<0.05$),弯角组和单侧组 X 线曝光次数无明显差异($P>0.05$)。3 组的骨水泥注入量比较,双侧组最多,弯角组次之,单侧组最少,组间两两比较差异有统计学意义($P<0.05$)。3 组的骨水泥渗漏率比较,单侧组最高,双侧组次之,弯角组最低,组间两两比较差异有统计学意义($P<0.05$)。3 组患者术后疼痛均明显缓解,术后 24h 及术后 3 个月 VAS 评分明显低于术前($P<0.05$),术后 24h 及术后 3 个月 VAS 评分比较无明显差异($P>0.05$),说明术后效果显著,而组间比较无明显差异($P>0.05$)。

3 讨论

自 1987 年 Galibert 和 Deramond 采用 PVP 治疗 1 例颈椎血管瘤取得成功后,PVP 技术逐渐被应用于 OVCF 的治疗。PVP 是指经皮通过椎弓根或椎弓根外向骨折的椎体内注入骨水泥,以达到稳定骨折、恢复椎体力学强度和刚度、防止椎体进一步压缩,从而起到缓解腰背部疼痛为目的的一种微创技术^[2]。

PVP 能够缓解胸腰椎骨折疼痛的原理:骨水



图 3 弯角组患者,女,75 岁 a 术前 X 线片示 L1 椎体压缩性骨折 b 术后正位 X 线片示骨水泥双侧充盈良好 c 术后侧位 X 线片示骨水泥无明显外溢 d 术后 CT 冠状位重建示骨水泥双侧充盈良好 e 术后 CT 矢状位重建示骨水泥无明显外溢 f 术后 CT 横断面示骨水泥充盈良好,未见明显外溢

Figure 3 Patient in the curved group, female, 75 years old. X-ray and CT imaging of bone cement dispersion after PCVP a Preoperative lateral X-ray: L1 vertebral compressive fractures b Postoperative anteroposterior X-ray: bone cement was well filled bilaterally c Postoperative lateral X-ray: there was no obvious leakage bone cement d Postoperative CT coronal reconstruction: bone cement was well filled bilaterally e Postoperative CT sagittal reconstruction: there was no obvious leakage bone cement f Postoperative CT cross-section: there was no obvious leakage bone cement

表 2 3 组的手术时间、X 线曝光次数、骨水泥注入量、骨水泥渗漏率及术前、术后 24h、术后 3 个月 VAS 评分

Table 2 The operation time, X-ray exposure times, bone cement injection volume, bone cement leakage rate and preoperative, postoperative 24 hours, postoperative 3 months VAS score of the three groups

	手术时间 Operation time (min)	X线曝光次数 X-ray exposure times	骨水泥注入量 (ml) Bone cement injection volum	骨水泥渗漏率 (%) Bone cement leakage rate	VAS评分 VAS score		
					术前 Preoperation	术后 24h Postoperative 24h	术后 3 个月 Postoperative 3 months
弯角组 Curved group	22.4±8.6 ^①	8.5±4.2 ^①	4.5±1.3 ^{①②}	9.3%(4/43) ^{①②}	7.8±1.2	2.4±1.2 ^③	1.3±0.5 ^③
单侧组 Unilateral group	20.5±10.8 ^①	9.2±3.8 ^①	3.4±1.2 ^①	28.6%(12/42) ^①	8.2±0.6	2.5±0.8 ^③	1.5±0.4 ^③
双侧组 Bilateral group	38.2±6.8	17.8±3.2	6.2±1.5	18.6%(8/43)	8.1±0.8	2.8±0.6 ^③	1.6±0.8 ^③

注:①与双侧组比较 $P<0.05$;②与单侧组比较 $P<0.05$;③与同组术前比较 $P<0.05$

Note: ①Compared with bilateral group, $P<0.05$; ②Compared with unilateral group, $P<0.05$; ③Comparison of the same group before operation, $P<0.05$

泥注入骨折椎体的骨小梁间隙中,能稳定骨小梁;分担骨小梁的压力,可使骨强度得到有效增强;骨水泥发热凝固过程产生的热效应破坏了病椎的周围神经末梢,缓解疼痛^[3]。

目前 PVP 的手术入路主要分为单侧与双侧经椎弓根穿刺两种,但选择何种入路方式更佳一直存在着争议^[4]。有研究认为骨水泥在伤椎体内弥散情况与缓解疼痛的效果相关,而双侧入路较单侧更有利于骨水泥广泛弥散,双侧入路更有优势^[5]。然而单侧入路因为有手术时间短、放射次数少、创伤小等优势,被大多数临床医师所选择^[6]。弯角椎体成形技术的出现解决了这个难题,其结合了单侧、双侧入路二者的优势。本研究结果显示,3 组术后 24h 及术后 3 个月 VAS 评分明显低于术前 ($P<0.05$),而 3 组间比较无明显差异 ($P>0.05$),说明 3 组患者术后腰背痛均得到明显缓解,临床效果显著,且止痛效果 3 组比较无明显差别。但弯角组与双侧组比较手术时间更短、X 线曝光次数更少,而与单侧组比较在骨水泥注入量、骨水泥渗漏率及术后复查 CT 评估骨水泥弥散情况方面都表现出明显的优势。

PVP 虽是一种微创技术,但仍有不可规避的风险及并发症,临床上以脊髓及神经根损伤、骨水泥渗漏和邻近椎体骨折最为多见^[7]。

脊髓及神经根的损伤大多是由于入针点选择偏内、穿刺角度过大以及骨水泥向椎管内渗漏造成^[8]。单侧入路 PVP 为追求骨水泥的填充效果,不局限于椎体一侧,往往会加大穿刺针内倾角度,从而增加了穿透椎弓根内侧壁,损伤脊髓及神经根

的几率。双侧入路 PVP 虽然不需要加大穿刺内倾角度,但因为是双侧操作,穿刺风险相对增加。PCVP 则是很好地解决了这个问题,从单侧入路,不要求强调穿刺内倾角度,最大限度降低了穿刺风险,通过弯角推注器到达椎体对侧,从而达到双侧注入骨水泥的效果,且节省了穿刺次数及透视时间^[9]。本研究中,虽然 3 组术后都无明显脊髓、神经根的损伤,但弯角组与单侧组在手术时间、X 线曝光次数方面相当,都明显低于双侧组。弯角组理论上看似比单侧组操作要求更高,操作时间更长,注入骨水泥更多,但实际操作中,弯角组操作步骤仅比单侧组多一步弯角注入器的置入,并未明显增加手术时间及 X 线曝光次数。

骨水泥的渗漏是 PVP 手术最常见的并发症,其发生率在 3%~75%^[10]。骨水泥渗漏一般有以下几种类型:骨水泥沿骨折裂隙渗漏到椎管、椎间盘、椎体前缘;渗漏到椎旁组织;沿穿刺针道渗漏;渗漏到血管^[11]。造成骨水泥渗漏的原因有:椎体终板和后缘骨皮质不完整;椎体压缩,椎体内阻力大,同时增加了注射压力;穿刺技术不熟练与操作不当,反复多次穿刺、过快过猛注射骨水泥、过早拔除穿刺针等;骨水泥的稀稠程度及注射量,骨水泥较稀时注入,渗漏率更高,太晚注入骨水泥则推注困难,也会导致渗漏,骨水泥注入量越大,发生渗漏的风险也越高^[12]。本研究结果结果显示,单侧组骨水泥渗漏率最高,考虑其主要是因为单侧入路,多数不能穿过椎体矢状位中线,骨水泥集中于椎体一侧,而且为了追求骨水泥充盈效果,往往会注入相对较多的骨水泥,从而使得椎体内压力较

大,造成骨水泥渗漏^[13]。双侧组行双侧椎弓根注入骨水泥,每侧骨水泥注入量相对较少,骨水泥渗漏较少。弯角组通过弯角注入器在椎体内扩开一条弧形通道,直至椎体对侧,在边退弯角注入器时边行多点注射,骨水泥先由经椎体前柱再向中柱弥散,处于低压弥散状态,随时可以观察和控制骨水泥弥散及渗漏情况,降低了骨水泥的渗漏率^[14]。

有研究报道,PVP 术后病椎及相邻椎体发生骨折的概率增加,分析其原因可能是骨水泥在病椎内弥散不均,椎体两侧的刚度不能均衡提高;病椎注入骨水泥后椎体刚度、强度明显增加,而相邻椎体因骨质疏松刚度、强度相对减弱;骨水泥沿病椎上下破裂的终板向椎间盘渗漏,椎间盘承受应力变化时的缓冲能力减弱,导致相邻椎体终板所承受压力不均匀^[15]。有限元模型分析^[16]认为骨水泥沿椎体周围环形分布可最大限度地降低邻近椎体骨折发生的风险,因此骨水泥在椎体内的均匀弥散及减少向椎间盘的渗漏极为重要。PCVP 通过弯角注入器行多点注射,骨水泥在椎体内沿弧形弥散填充,提供了理想的生物力学支撑,有效降低了病椎及相邻椎体骨折的几率。本研究因为随访时间较短(术后随访 3 个月),3 组都未见患者因相邻椎体骨折而再次就诊。

总之,PCVP 作为一种新兴技术,具有操作简单、手术时间短、X 线透视次数少、创伤相对小等优势,同时可减少骨水泥渗漏等 PVP 手术所存在的并发症,是治疗胸腰椎 OVCF 的有效微创手术方法。

4 参考文献

1. Sun H, Li C. Comparison of unilateral and bilateral percutaneous vertebroplasty for osteoporotic vertebral compression fractures: a systematic review and meta-analysis[J]. J Orthop Surg Res, 2016, 11(1): 156.
2. Clarencon F, Fahed R, Gabrieli J, et al. Safety and clinical effectiveness of percutaneous vertebroplasty in the elderly(≥ 80 years)[J]. Eur Radiol, 2016, 26(7): 2352-2358.
3. Yang EZ, Xu JG, Huang GZ, et al. Percutaneous vertebroplasty versus conservative treatment in aged patients with acute osteoporotic vertebral compression fractures: a prospective randomized controlled clinical study[J]. Spine, 2016, 41(8): 653-660.
4. Teles AR, Mattei TA. Vertebral augmentation in thoracolumbar compression fractures: a critical review on available evidence and ongoing controversies[J]. Minerva Ortop Traumatol, 2015, 66(1): 25-39.
5. Saracen A, Kotwica Z. Treatment of multiple osteoporotic vertebral compression fractures by percutaneous cement augmentation[J]. Int Orthop, 2014, 38(11): 2309-2312.
6. Yang JY, Lee JK, Cha SM, et al. Clinical results of unilateral partial vertebroplasty(UPVP) in osteoporotic vertebral fracture[J]. J Korean Soc Spine Surg, 2011, 18(2): 64-69.
7. Saracen A, Kotwica Z. Complications of percutaneous vertebroplasty: an analysis of 1100 procedures performed in 616 patients[J]. Medicine(Baltimore), 2016, 95(24): e3850.
8. Kalevski S, Haritonov D, Peev N, et al. Surgical complications and unwated events in the modern percutaneous vertebroplasty treatment[J]. Scripta Medica, 2016, 48(3): 47-55.
9. 张军, 王新虎, 左春光. 定向弧形骨钻用于椎体成形术的实验研究[J]. 中国微创外科杂志, 2014, 14(7): 653-657.
10. Hong SJ, Lee S, Yoon JS, et al. Analysis of intradiscal cement leakage during percutaneous vertebroplasty: multivariate study of risk factors emphasizing preoperative MR findings[J]. J Neuroradiol, 2014, 41(3): 195-201.
11. Zhu SY, Zhong ZM, Wu Q, et al. Risk factors for bone cement leakage in percutaneous vertebroplasty: a retrospective study of four hundred and eighty five patients[J]. Int Orthop, 2016, 40(6): 1205-1210.
12. Park JH, Kim HS, Kim SW. Cement leakage into adjacent vertebral body following percutaneous vertebroplasty[J]. Korean J Spine, 2016, 13(2): 74-76.
13. Jin YJ, Yoon SH, Park KW, et al. The volumetric analysis of cement in vertebroplasty: relationship with clinical outcome and complications[J]. Spine, 2011, 36(12): E761-772.
14. 熊森, 毛克亚, 韩振川, 等. 应用弯角椎体成形装置修复胸腰段骨质疏松性椎体压缩骨折[J]. 中国组织工程研究, 2016, 20(17): 2496-2502.
15. Takahara K, Kamimura M, Moriya H, et al. Risk factors of adjacent vertebral collapse after percutaneous vertebroplasty for osteoporotic vertebral fracture in postmenopausal women[J]. BMC Musculoskelet Disord, 2016, 17(1): 1-7.
16. Baek SW, Kim C, Chang H. The relationship between the spinopelvic balance and the incidence of adjacent vertebral fractures following percutaneous vertebroplasty[J]. Osteoporos Int, 2015, 26(5): 1507-1513.

(收稿日期:2017-01-01 修回日期:2017-02-28)

(英文编审 蒋欣/贾丹彤)

(本文编辑 李伟霞)