

# 经皮椎体强化术并发症发生及对策

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**【摘要】** 经皮椎体强化术(PVA)包括经皮椎体成形术(PVP)、经皮椎体后凸成形术(PKP),目前已成为治疗疼痛性椎体病变的有效介入手段。总体上,PVA 并发症发生率较低,但严重并发症一旦发生,即严重影响手术疗效和患者预后。PVA 并发症可分为骨水泥渗漏相关并发症、脂肪栓塞、骨水泥特质反应、生物力学相关并发症及操作相关并发症。本文就 PVA 并发症与防治对策进行综述,建议严格掌握手术适应证,严格遵守操作规程,尽可能减少或避免并发症发生。

**【关键词】** 经皮椎体强化术;经皮椎体成形术;经皮椎体后凸成形术;并发症

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**Percutaneous vertebral augmentation: its complications and countermeasures** SUN Gang Department of Medical Imaging, General Hospital of Jinan Military Area Command, Jinan, Shandong Province 250031, China

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**【Abstract】** Nowadays, percutaneous vertebral augmentation (PVA), which includes percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP), has become the most effective interventional method for painful vertebral lesions. Generally speaking, the complication incidence of PVA is lower, but once severe complications occur, the operative outcome and prognosis will be seriously affected. The complications caused by PVA include bone cement leakage-related complications, fat embolism, idiosyncratic reaction to bone cement, biomechanics-related complications and operation-related complications. This article aims to make a review about the complications of PVA and their prevention and treatment. Strict observation of operation indications and operating instructions are strongly suggested in order to reduce or avoid the occurrence of complications as much as possible. (J Intervent Radiol, 2017, 26: 769-774)

**【Key words】** percutaneous vertebral augmentation; percutaneous vertebroplasty; percutaneous kyphoplasty; complication

近 10 余年来,经皮椎体强化术(percutaneous vertebral augmentation, PVA)包括经皮椎体成形术(percutaneous vertebroplasty, PVP)、经皮椎体后凸成形术(percutaneous kyphoplasty, PKP)在国内外受到广泛关注。其手术创伤小、缓解疼痛效果良好,已逐渐成为治疗椎体良恶性骨折等病变的重要方法之一<sup>[1-2]</sup>。但随着该技术在临床上不断推广和应用,相关并发症也逐渐增多。PVA 并发症可分为骨水泥渗漏相关并发症、脂肪栓塞、骨水泥特质反应、生物力学相关并发症及操作相关并发症。现结合国内外文献,对 PVA 并发症与防治对策作一综述,以期为

临床实践提供参考。

## 1 骨水泥渗漏相关并发症

PVA 术实施需通过经皮穿刺方式,在一定压力下向病变区域内注入聚甲基丙烯酸甲酯(PMMA)类骨填充材料——骨水泥,由此可能导致骨水泥在治疗区域外渗漏。PVP 和 PKP 骨水泥渗漏类型,按渗漏部位包括椎管内硬膜外渗漏、神经孔渗漏、椎间盘渗漏、脊柱旁软组织渗漏、椎旁静脉渗漏和穿刺针道渗漏等;按渗漏路径包括 Yeom 等<sup>[3]</sup>报道的 B 型(骨水泥沿椎基底静脉渗漏至椎体后缘)、C 型(沿椎体骨皮质缺损渗漏,可发生在椎体周边任何部位如椎间盘、椎体旁、椎体后缘等)和 S 型(沿椎间静脉渗漏)等 3 种类型。多项研究报道临床上 PVP 和

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PKP 骨水泥渗漏较常见,CT 为最敏感发现方法。此外,骨水泥渗漏也可迁移至循环系统。骨水泥渗漏大多无症状,症状性骨水泥渗漏少见<sup>[4-8]</sup>。症状性骨水泥渗漏主要分为神经系统压迫性并发症与循环系统栓塞性并发症。

### 1.1 神经系统压迫性并发症

渗漏骨水泥的直接压迫和骨水泥聚合反应的热效应,均损伤神经根或脊髓,导致可逆性或持续性神经根性疼痛与脊髓压迫症状<sup>[8-10]</sup>。有学者认为早期手术减压并取出渗漏骨水泥,具有良好的临床效果<sup>[11-12]</sup>。但 Teng 等<sup>[13]</sup>报道 PVP 术后 3 例症状性椎管内骨水泥渗漏患者,于 4 d 至 8 个月后接受手术减压并取出渗漏骨水泥,术中发现硬膜与椎管内有纤维性粘连,考虑与骨水泥聚合热效应有关;分别随访 13 个月、3 年、4.75 年,患者下肢运动及大小便功能恢复不佳。Belkoff 等<sup>[14]</sup>研究发现,骨水泥聚合热效应温度可达 113℃。值得注意的是,Omidi-Kashani 等<sup>[15]</sup>报道 1 例 PVP 导致椎管内骨水泥渗漏患者,于术后 2 个月发生迟发型坐骨神经痛。

### 1.2 循环系统栓塞性并发症

循环系统栓塞性并发症可分为体静脉与心脏系统并发症和体动脉系统并发症。

体静脉与心脏系统并发症——骨水泥渗漏至椎体静脉丛可迁移至下腔静脉系统,导致肺动脉栓塞、心脏异物甚至穿孔。肺动脉栓塞可无症状,据报道发生率可达 4.6%<sup>[16]</sup>。肺动脉栓塞症状可立即或延迟发生。经典症状为呼吸困难、呼吸急促、心动过速、发绀、胸痛、咳嗽、咯血、头晕和出汗等<sup>[17-19]</sup>。处理措施包括吸氧、抗凝治疗、静脉注射激素;必要时可行开放手术或导管介入取出渗漏骨水泥<sup>[20-23]</sup>。渗漏骨水泥迁移至心脏可导致血流动力学紊乱,甚至心肌穿孔,患者可出现严重胸痛,需要开放手术治疗<sup>[24-26]</sup>。骨水泥渗漏至肾静脉可产生可逆性肾功能损害<sup>[27]</sup>。

体动脉系统并发症——骨水泥渗漏至体动脉系统较为少见。Tsai 等<sup>[28]</sup>、Yazbeck 等<sup>[29]</sup>分别报道 1 例 PVP 治疗疼痛性椎体转移瘤发生脊髓前动脉综合征,渗漏骨水泥均经椎间动脉进入脊髓前动脉。Iliopoulos 等<sup>[30]</sup>报道 1 例渗漏骨水泥迁移至左足背动脉,患者出现左足背伸无力,足背动脉和胫后动脉搏减弱,经肝素治疗后症状缓解。Amoretti 等<sup>[31]</sup>报道 1 例 PVP 治疗乳腺癌椎体转移瘤患者,发生无症状性骨水泥经腰动脉渗漏至腹主动脉。也有病例报道显示,开放手术结合骨水泥灌注发生骨水泥经 L3 动脉进入膝下动脉<sup>[32]</sup>。渗漏骨水泥进入动脉机制

尚不完全清楚。可能为穿刺针进入或贴近骨小动脉,骨水泥先填充静脉,后逆向流动进入供血动脉和椎间动脉;或椎体转移性肿瘤内有动静脉漏,填充静脉的骨水泥逆向流动进入动脉。骨水泥也可通过先天性心脏病(右向左分流)进入体动脉循环。Scroop 等<sup>[33]</sup>报道 1 例骨水泥通过未闭的卵圆孔引起脑动脉栓塞。

### 1.3 椎管内静脉压升高相关并发症

Mattei 等<sup>[34]</sup>报道急性脊髓硬膜下血肿并椎管内积气 1 例,患者全身麻醉下行 PVP 苏醒后即感左上下肢麻木,左下肢无力,影像学检查显示椎管内血肿、少量骨水泥渗漏入椎管内静脉丛;遂行椎板切除减压术,术后 3 个月左下肢肌力恢复,但左上下肢麻木感仍无缓解。脊髓硬膜下血肿并椎管内积气产生机制尚不完全清楚,推测与骨水泥渗漏入静脉,导致静脉压力增高有关。Bhide 等<sup>[35]</sup>报道 1 例 62 岁女性经 PVP 治疗 T12 椎体骨质疏松性压缩骨折,术中出现截瘫,CT 检查显示 T9~L3 平面骨水泥渗漏并椎管内积气;遂行多节段椎板切除减压术,取出渗漏骨水泥,但症状无缓解;术后 2 周 MRI 显示 T9~12 段脊髓肿胀,术后 3 周症状逐渐加重,C3 水平以下出现感觉障碍,MRI 复查显示 C3~T9 段脊髓肿胀,诊断为亚急性进行性上行脊髓病。此病发生机制尚不完全清楚,可能与骨水泥渗漏压迫脊髓,导致局部静脉充血,继发缺血有关。

## 2 脂肪栓塞

Aebli 等<sup>[36]</sup>用羊进行实验发现,骨水泥灌注后可增加椎体内压力,促使椎体内游离脂肪滴进入椎静脉,导致脂肪栓塞。Kraus 等<sup>[37]</sup>报道 1 例 60 岁男性因 T12 骨髓瘤行 PVP 治疗,术后出现右下肢轻度肿胀、下地行走疼痛,多普勒超声检查显示右下肢深静脉脂肪栓塞;遂予经导管取栓术,辅以抗凝治疗,症状缓解。

## 3 骨水泥特质反应

骨水泥注入后在体内聚合过程所产生的热效应,对周围组织及神经有一定的损伤。术后患者可出现一过性疼痛复发和加重,在排除骨水泥渗漏和继发骨折情况下,一般多视为 PMMA 热化学炎性反应,可用麻醉剂止痛或口服地塞米松处理,数日后即可缓解。Kelekis 等<sup>[38]</sup>报道 4 例 PVP 术后疼痛患者,采用 0.2%利多卡因加冰 0.9%氯化钠溶液 100~200 ml 对手术区域进行局部冲洗灌注 10~20 min,

以减轻局部组织和神经热损伤和化学刺激,治疗后疼痛消失。骨水泥惰性单体渗漏可引起毒性反应,具体机制尚不清楚。Vasconcelos 等<sup>[39]</sup>报道 1 例椎体血管瘤患者 PVP 术中发生过敏反应,表现为一过性低血压及发热症状,立即作抗过敏及对症治疗,症状消失。Zarattini 等<sup>[40]</sup>报道 1 例 64 岁女性骨质疏松性 T12 椎体压缩骨折患者接受 PVP 治疗后发生上行性强直阵挛综合征,考虑可能与骨水泥单体进入脑脊液,导致脊髓抑制功能减弱有关。该患者手术过程顺利,术后 40 min 诉腰腿部疼痛,双下肢反复性肌阵挛,持续约 15 s,伴呼吸困难、窦性心动过速,动脉血气分析显示低氧血症和代谢性酸中毒,遂气管插管、上呼吸机,静脉用药对症处理;术后 2 d 增强 MRI 显示马尾神经根增强,表明脊膜炎性反应,术后 7 d 患者康复。

#### 4 生物力学相关并发症

##### 4.1 椎体新发骨折

Tanigawa 等<sup>[41]</sup>报道对 PVP 术后 76 例患者(206 节椎体)进行平均 11.5 个月随访,结果显示术后 3 个月内 1/3 患者出现新发椎体骨折,超过一半发生于邻近椎体。Boger 等<sup>[42]</sup>研究发现骨水泥刚度高于骨质疏松性椎体松质骨 7~10 倍,强化椎体椎间盘在承受载荷应力变化时的缓冲能力降低,导致大部分负荷向相邻椎体终板不均匀传递,最终导致骨折发生。但也有研究表明,PVP 术后并不会增加邻近椎体骨折,新发骨折是自然病程结果。Sun 等<sup>[43]</sup>对 175 例 PVP 术后患者随访 12 个月,发现新发椎体骨折 37 例(21.1%),与患者骨密度及胸腰结合部位密切相关。Klazen 等<sup>[44]</sup>对比分析 91 例行 PVP 和 85 例行保守治疗患者骨质疏松性椎体压缩骨折数据,发现两组新发椎体骨折比例无明显差异,且新发骨折发生于原骨折椎体相邻或非相邻椎体的风险亦无明显差异。

##### 4.2 椎体内骨水泥松动与移位

Lin 等<sup>[45]</sup>报道 23 例 PVP 后疼痛缓解不佳或疼痛复发的随访资料,MRI 检查显示 41 个强化椎体中有 22 个椎体内部出现裂隙,其中 8 个骨水泥与骨质间有液性分界面,提示骨水泥与椎体骨质无粘合。Li 等<sup>[46]</sup>、He 等<sup>[47]</sup>分别报道对 PVP 治疗后椎体再骨折进行再次 PVP 治疗,效果良好。治疗椎体再骨折的机制尚不完全清楚,可能与骨质疏松自然病程、椎体裂隙征、骨水泥灌注量不足有关。Wagner 等<sup>[48]</sup>报道 PVP 治疗骨质疏松性 L3 椎体压缩骨折 1 例,

术后 1 个月再次出现腰部严重疼痛,影像学检查发现椎体内骨水泥块前移 1 cm,并突破椎体前缘,进入腹膜后间隙。Nagae 等<sup>[49]</sup>报道开放手术结合骨水泥灌注治疗性腺外生殖细胞瘤侵及腰骶结合部骨质 1 例,术后 30 个月影像学检查发现椎体内骨水泥明显前移,术后 34 个月患者出现肠梗阻症状,影像学检查发现骨水泥迁移入小肠;开放手术发现腹腔内小肠与椎体严重粘连,取出小肠内骨水泥,患者肠梗阻症状缓解。

#### 5 操作相关并发症

##### 5.1 特发性蛛网膜下腔出血

非外伤性及非动脉瘤性蛛网膜下腔出血已证实的原因,主要有毛细血管扩张症、静脉窦狭窄、过度体力消耗、脑肿瘤、脑膜脑炎、瓦式呼吸、凝血障碍、严重动脉高压、血管炎等<sup>[50-54]</sup>。Lim 等<sup>[55]</sup>报道 2 例老年女性 PVP 治疗后特发性蛛网膜下腔出血,均在注入骨水泥后发生剧烈头痛等症状,CTA、MRA、DSA 检查未发现颅内血管病变。PVP 治疗后发生特发性蛛网膜下腔出血的原因,主要为患者俯卧治疗体位及瓦式呼吸增加胸内压,阻碍颈内静脉回流,导致颅内静脉压升高;操作过程的穿刺、局部麻醉、骨水泥注入产生的疼痛与焦虑,导致动脉压升高。因此,PVP 术治疗体位、心肺功能监测、血压控制、充分镇痛,十分重要。

##### 5.2 脊髓麻醉

脊髓麻醉并发症与麻醉药弥散相关。Balkarli 等<sup>[56]</sup>报道对 1 例 68 岁女性骨质疏松性 L1 椎体压缩骨折行 PVP 治疗,2%普鲁卡因局部麻醉,术后患者发生双下肢肌力与感觉减退,体检发现双下肢肌力 0 级,感觉平面位于 T10,逐渐上升至 T5,血压 90/50 mmHg;静脉滴注 0.9%氯化钠溶液 500 ml,肌内注射培他米松 6 mg,30 min 后感觉平面降至脐平面,血压 110/90 mmHg,CT 检查未发现骨水泥渗漏入椎管内;术后 4 h,患者肌力与感觉完全恢复正常。

##### 5.3 颅内低压综合征与蛛网膜囊肿

PVA 穿刺可导致脑脊液漏。Chen 等<sup>[57]</sup>报道 1 例 PVP 治疗骨质疏松性 T12 椎体压缩骨折,术后疼痛明显缓解;数小时后患者诉直立位 5 min 即出现严重头痛、恶心、呕吐和颈部僵硬,卧位症状缓解,MRI 检查显示脑脊液在 T11~L1 水平硬膜外腔后部聚集,并有脑脊液漏,水化治疗与卧床休息 5 d 后症状消失。Mao 等<sup>[58]</sup>报道 1 例 PVP 治疗 L3 椎体疼痛性胰腺癌转移瘤,术后 6 个月患者诉下背部疼

痛并向左下肢放射,进行性行走困难,MRI 显示 L2~3 水平蛛网膜囊肿,压迫硬膜囊;手术切除囊肿,术中发现囊肿与蛛网膜下腔在 L3 椎弓根处相通,囊内容物与脑脊液相同,病理检查显示囊肿壁由非特异性纤维结缔组织构成,术后患者症状缓解。囊肿发生,考虑与 PVP 经椎弓根穿刺操作损伤有关。

#### 5.4 动脉损伤

PVA 穿刺途径不当或椎弓根外入路可导致动脉损伤。Heo 等<sup>[59]</sup>报道 1 例经椎弓根外入路 PVP 治疗骨质疏松性 L2 椎体压缩骨折,术后即刻疼痛明显缓解,但 2 h 后左下肢发生剧烈放射性疼痛,镇痛剂无效,收缩压由 130 mmHg 降至 95 mmHg,CT 复查显示腹膜后血肿,DSA 显示左侧 L2 节段动脉远端出血,用微弹簧圈栓塞;术后 40 d 超声引导下穿刺抽吸出陈旧性血液 500 ml,术后 47 d 患者痊愈出院。Puri 等<sup>[60]</sup>报道用导管圈栓塞治疗 PVP 术后腰动脉假性动脉瘤 2 例,效果良好。操作过程中误穿腹主动脉也有报道<sup>[61]</sup>。

#### 5.5 感染

PVP 创口小,感染概率低,一般严格遵照无菌操作情况下极少发生,但也有少数学者报道 PVP 术后感染患者。Walker 等<sup>[62]</sup>报道椎体切除术治疗 PVP 术后椎体骨髓炎 2 例。Alfonso-Olmos 等<sup>[63]</sup>报道 1 例 L2 椎体压缩骨折伴免疫抑制患者接受 PVP 治疗后出现高热、手术部位疼痛,MRI 显示 L2 椎体炎性改变,抗生素治疗 1 周无效;予以前入路椎体清除、自体髂骨植入、后入路内固定术,并辅以抗生素治疗 1 周,戴腰部支具 3 个月;2 年后随访,患者疼痛消失,神经功能无异常,植骨融合好。Soyuncu 等<sup>[64]</sup>报道 PVP 术后椎体后硬膜外脓肿形成 1 例,术后 1 周出现发热,疼痛加重,外科引流与抗生素治疗效果不佳;后予以 T11、T12 部分椎板切除术并清除脓液,术后对症处理,患者痊愈出院。PVP 术前详细了解病史,有助于避免术后感染并发症发生。

#### 5.6 椎体附件与肋骨骨折

Layton 等<sup>[65]</sup>对 PVP 治疗 552 例患者共 1 000 节段椎体压缩骨折资料进行分析,发现 7 例发生肋骨骨折,1 例受治椎体横突骨折。Evans 等<sup>[66]</sup>报道,PVP 治疗的 488 例中有 7 例术后 24 h 内发生肋骨骨折。Lieberman 等<sup>[67]</sup>报道 PKP 治疗骨质疏松性椎体压缩骨折 30 例,2 例发生肋骨骨折,认为与俯卧位操作有关。对于肋骨骨折,可予固定及止痛处理。本中心认为,肋骨骨折是重度骨质疏松患者接受 PVA 治疗较易发生的并发症之一,主要原因是进针操作中推

针及旋转力量过大,导致胸腔与手术台发生挤压。采用外科锤敲击推进穿刺针,操作尽可能轻柔,可减少骨折发生率。

总之,PVA 作为一种微创介入疗法,创伤小,疼痛缓解效果好,已受到临床上广泛肯定。应重视其并发症对手术疗效和患者预后的影响,严格掌握手术适应证,遵守操作规程,尽可能减少或避免并发症发生。应熟悉并发症各种表现与处理,使该技术更好地为患者服务。

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