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·综 述·

经皮椎弓根钉内固定术治疗胸腰椎骨折的研究进展

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[摘 要] 胸腰椎骨折是骨科的常见骨折之一,传统后路开放椎弓根钉内固定术临床效果确切,但存在手术创伤大、出血多、住院时间长、术后并发症多等缺点,易出现术后顽固性腰背痛。随着脊柱外科技术的发展,经皮椎弓根钉内固定术因其创伤小、出血少、住院时间短、即刻固定效果好、对脊柱后方结构损伤较小、术后疼痛缓解明显、感染率低等优点,被广泛应用于治疗胸腰椎骨折;且随着手术器械不断改进、辅助手段持续丰富,其临床效果也不断提高。但微创手术有其局限性,须严格掌握适应证。本文就经皮椎弓根钉内固定术的解剖学基础、发展沿袭、适应证及禁忌证、并发症作一综述,以期为临床胸腰椎骨折的治疗提供参考。

[关键词] 椎弓根钉;微创;胸腰椎骨折;内固定

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Progress in the treatment of percutaneous pedicle screw internal fixation for thoracolumbar fracture

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Abstract: Thoracolumbar fracture is one of the most common fractures in orthopedics. Traditional posterior open pedicle screw internal fixation has definite clinical curative effect, but there are many shortcomings, such as large surgical trauma, excessive blood loss, long hospital stay and a variety of postoperative complications. Also, postoperative intractable low back pain has been reported. As the development of spinal surgery techniques, percutaneous pedicle screw internal fixation has been widely used in the treatment of thoracolumbar fracture due to its advantages of less trauma, less blood loss, shorter hospital stay, better immediate fixation effect, less damage to the posterior spinal structure, more significant postoperative pain relief, lower infection rate and so on. And with the continuous improvement of surgical instruments and enrichment of auxiliary means, its clinical effect is also improving. However, minimally invasive surgery has its limitations and the indications must be strictly controlled. This article reviews the anatomical basis, development, indications, contraindications and complications of percutaneous pedicle screw internal fixation, in order to provide a reference for the clinical treatment of thoracolumbar fracture.

Keywords: pedicle screw; minimally invasive; thoracolumbar fracture; internal fixation

随着交通业和工业的发展,交通事故、高处坠落伤和火器伤已成为导致脊柱骨折、脊髓损伤最主要的原因[1]。胸腰椎骨折在脊柱骨折中约占 90%,其中 T_{11} ~ L_2 节段约占 60% ~ 70%[2-4]。这是由于 T_{11} ~ L_2 节段从活动较少且有肋骨和胸骨与之相关联的胸椎过渡到活动性较大的腰椎,这一区域承受着巨大的生物力学应力,易发生外伤性骨折。保守治疗一般适用于胸腰椎稳定性骨折,且患者需长期卧床、佩戴支具下床、长期服用镇痛药物。传统开放手术多采用后正中切开复位后椎弓根钉内固定,矫形可靠,但同时存在暴露范围广、椎旁组织损伤大、失血量多、并发症多、恢复慢等缺点,此外,术中采用的椎旁肌骨膜下剥离以及持续牵开器撑开容易引起肌肉缺血坏死、去神经化和纤维化,导致术后腰背部慢性疼痛甚至腰椎手术失败综合征,严重影响患者预后[5-6]。如何在最大可能减少医源性创伤的同时解决患者的疾患一直是外科医生追求的目标。经皮椎弓根钉内固定术(percutaneous pedicle screw fixation, PPSF)避免了传统后路切开复位后椎弓根钉内固定术的缺点,现已被广泛应用于胸腰椎骨折的治疗[6-7]。本文现就 PPSF 的解剖基础、发展沿袭、适应证、禁忌证以及并发症作一综述,以期为临床治疗胸腰椎骨折提供参考。

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1 PPSF 的解剖学基础

椎弓根上、下切迹围成椎间孔,有脊神经和血管穿过。椎体前方分布着腹主动脉、下腔静脉、植物神经和内脏器官,椎弓根内侧缘邻近脊髓或马尾,仅存在 2 ~ 3 mm 的间隙,且存在大量血管丛。脊神经紧挨着椎弓根内侧缘下行,贴下切迹出椎间孔,走行于下位椎弓根外侧附近。

胸腰椎椎弓根从上到下呈逐渐增粗趋势,左右径在 T_5 时为 4.5 mm,在 L_5 时为 18 mm,上下径一般略大于左右径。相对于椎体矢状面,椎弓根中心轴外倾,所成角度在胸椎从上到下呈递减趋势,在 T_{12} 达最小值;在腰椎从上到下呈递增趋势,在 L_5 达最大值,约 30°。相对于椎体横断面,椎弓根总体呈上倾趋势,所成角度

在胸椎大部分为15°~17°,从T_{10}开始呈减小趋势,在L_1~L_4接近于0°,在L_5出现例外,略向下倾。沿椎弓根长轴,自尾部到椎体前缘皮质的距离约为40~45 mm。生物力学实验表明:拔出力强度60%由椎弓根提供,椎体骨松质可增加15%~20%,到达椎体前缘骨皮质不穿透时可增加16%,穿透骨皮质时可再增加20%~25%[8]。因此,PPSF术前应仔细查看影像学资料,辨认相关节段椎弓根的形态学变化,术中穿刺时应及时调整角度,并选择合适直径和长度的螺钉。进针点多选择右侧椎弓根2~3点钟和左侧椎弓根9~10点钟位置,以10°~15°内倾角进入,且保持与椎体上终板平行;当侧位片上显示针尖达椎体后壁时,正位片上针尖应未到达椎弓根内壁,当侧位片上显示穿刺针进入椎体的长度约为椎体前后径的3/4时,应当停止进针[9]。

腰背部血供呈节段性分布,脊柱血供主要来源于由邻近大动脉发出的节段性动脉(如肋间后动脉和腰动脉等)及其前、后支[10]。后支在椎间孔旁分为横突前支、脊支和背支;背支在横突下方下行,绕向后下方,供应上下关节突及棘突。因此,后支滋养腰背深层肌、椎板、关节突、棘突及其相关韧带。对应静脉于横突下与同名动脉伴行,并与对侧和相邻同名静脉在棘突和横突周围汇聚成静脉丛。

腰背部神经支配也具有节段性特征。脊神经穿出椎间孔后发出后支,在下位横突的上缘和上关节突的外侧向后向下向内侧走行,并分为内、外侧支,有时还有中间支。内侧支继续向后向下达到椎板的后面再转向下,约跨2~3个节段,交叉分布,支配关节突关节连线以内的关节囊、多裂肌及其他软组织,近中线处穿胸腰筋膜至皮下。外侧支则向后向下向外侧走行,发出分支支配关节突关节连线以外的背深层肌,下行约2~3个节段后穿过筋膜达皮下。近年来有研究表明,除了内外侧支,还存在中间支,主要支配最长肌[11]。

后路开放手术将椎旁肌肉剥离至关节突外缘,甚至暴露横突,以获得进钉的解剖标志,术中还采用撑开器持续侧向牵开,此时脊神经后支主干和内、外侧支均处于张力状态,尤其是内侧支;若操作幅度过大,很可能出现牵拉损伤,进而导致周围腰背深层肌的失神经化。同时,节段静脉后支在开放手术中也易损伤,若电凝止血则可能伤及脊神经后支内侧支。PPSF则仅需经体表小切口经肌间穿刺置入工作通道,在可视化条件下行垂直操作,可极大程度避免上述血管神经损伤。

2 PPSF治疗胸腰椎骨折的发展

1995年Mathews等[12]将前人用于临时外固定的经皮腰椎椎弓根穿刺术加以运用,在X射线透视辅助下施行了经皮腰椎椎弓根螺钉内固定术。2002年Foley等[13]首先对退行性腰椎病变进行经皮椎弓根螺钉内固定融合,其使用独特固定系统(Sextant系统),先用螺钉延长套筒辅助置钉,再用特制的插入装置将预弯的钢棒经一小切口插入,并置于肌肉下完成钉棒固定。之后有学者在原有的Sextant系统上增加了具有提拉复位及畸形矫正作用的提拉杆,并将适用范围扩大到胸腰椎骨折,然而多轴螺钉的使用以及借助延长工具在体表完成的间接复位使其撑开和加压作用不如单轴螺钉明显,因而矫形效果也劣于开放手术[14]。Yang等[14]开发了具有弯曲角度的新型螺钉,视椎体压缩程度来选择合适角度的螺钉,复位时将螺母拧紧力转化为撑开力,以促进伤椎高度的恢复和Cobb角的改善;且在钉尾增加了一个反方向旋转的螺钉,以改善复位效果,避免螺母松动,但尚无大样本和长期随访的研究,故有待进一步研究。近年来不断有临床研究表明,治疗胸腰椎骨折时,PPSF具有损伤小、出血少、住院时间短、即刻固定可靠、疼痛改善好等优点,这促使其内固定装置和手术器械不断优化,临床疗效也不断改善[15-18]。但部分学者认为,相较于传统开放手术,应用PPSF的患者在术后即刻及随访中,伤椎前缘高度、后凸Cobb角、伤椎楔形角、椎管侵袭指数等均无明显优势[16-18]。

虽然长节段固定更加牢固,但会增加创伤,加速邻近椎间盘退变,损失更多运动节段。短节段内固定能最大限度保留脊柱的运动功能,与长节段固定相比,临床和影像学结果并无显著差异,故短节段内固定成为了后路椎弓根钉手术的主流方式,PPSF亦是如此[19]。虽然后外侧骨融合不能在PPSF中进行,但已有研究报道,胸腰椎骨折的开放手术中,融合和不融合术式的临床和影像学结果相似[20-21]。目前,不融合的短节段经皮椎弓根钉内固定术的应用范围已被扩大到了B1型骨折,并取得了良好的效果[22]。

任何一项新技术都应当接受长期的实践检验,PPSF也不例外。常规的跨伤椎置钉方式,以螺钉撑开上下椎体来牵拉邻近椎间盘和前后纵韧带,实现间接复位,故对伤椎的复位、后凸畸形的矫正可能不够理想。在长期随访中,跨伤椎置钉还可能出现螺钉松动、退钉、断裂、伤椎高度丢失及后凸矫正量丢失等并发症[23-24]。针对这些问题,不断有学者提出改进方案。伤椎置钉技术最早由Dick等[25]提出,其认为附加伤椎置钉固定优势明显,轴向承载能力、抗屈能力和抗扭转能力分别增加了160%、48%和38%。后续的相关生物力学研究和临床研究(包括一项涉及1 280例患

者的 Meta 分析)也为伤椎置钉技术的可行性和优越性提供了依据,综合多项研究可知,附加伤椎置钉的 PPSF 优势如下:可避免四边形效应和悬挂效应;减少了应力集中,可避免断棒断钉;对伤椎施加了直接向前顶推力,有利于改善后凸畸形;可恢复伤椎前缘高度,增加前中柱抵抗力;可避免复位时过度牵拉损伤椎间盘[3,26-27]。Wang 等[28]运用经皮附加伤椎置钉的 6 钉技术治疗无神经损伤的胸腰椎骨折患者,并与经皮 4 钉技术和开放 4 钉技术对比,结果显示,在出血量、手术时间、术后住院时间、视觉模拟评分、Oswestry 功能障碍指数等方面,经皮组均明显优于开放组,但经皮组之间差异无统计学意义;3 组后凸 Cobb 角、伤椎前缘高度、伤椎自身角均有显著改善;开放组在纠正矢状面 Cobb 角方面要优于经皮 4 钉组,经皮 6 钉组矫正效果与开放组相当;随访中,经皮 6 钉组矢状面 Cobb 角的矫正量损失最小。

PPSF 的间接复位可使伤椎外形基本恢复,但伤椎实际上呈“蛋壳”样改变,伤椎本身及其上、下间隙不能承重,载荷主要通过内固定传导。有学者认为,伤椎置钉并不能有效改善脊柱轴向承载能力及伤椎稳定性,这也解释了部分研究中所发现的术后矫正丢失及内固定失败。为了解决这一问题,近年来有学者提出了经伤椎椎弓根植入自体或异体骨或者骨水泥,以改善伤椎内部结构变化,即“伤椎强化术”[29]。Korovessis 等[30]对 36 例新鲜单节段胸腰椎骨折(AO 分型为 A2、A3、B2 型)患者行 PPSF 联合后凸成形术治疗,有效减少了脊柱畸形和疼痛,并发症少,疗效可靠。然而,Elmasry等[31]的生物力学研究报告显示,PPSF 联合后凸成形术并没有近期的术后生物力学优势,长期生物力学性能仍有待进一步验证。Caruso 等[32]对 49 例胸腰椎骨折患者行 PPSF 联合后凸成形术治疗并随访 1 年,结果显示,附加伤椎置钉比联合后凸成形术保持了更有效的后凸矫正量。

随着内窥镜及影像技术的迅速发展,微创内固定由先前的 PPSF 逐渐发展为内窥镜辅助或导航监视下的椎间融合、椎弓根螺钉内固定等[33-34]。3D 打印导板导航辅助 PPSF 已经通过尸体试验论证了其置钉的准确性,并在临床得到了实际应用,切实提高了置钉准确性,缩短了手术时间,减少了出血量和放射暴露[35-36]。Yang 等[37]治疗 A3 型胸腰椎骨折时采用 O 型臂导航辅助 PPSF,疗效可靠;与开放手术相比,能提供术中实时图像及置钉轨迹的 O 型臂导航经皮置钉手术出血较少、住院时间较短、术后疼痛较轻、置钉准确率明显提高、放射暴露明显减少,影像学结果相当。Fomekong 等[38]利用术中三维 C 型臂透视导航技术为 66 例患者经皮置入 276 枚椎弓根螺钉,准确率达99.6%,术后未见明显手术相关并发症。计算机辅助骨科手术(computer assisted orthopaedic surgery,CAOS)综合利用当今先进的医学影像仪器(CT、MRI、PET、DSA 以及超声成像)结合立体定位系统,对人体肌肉骨骼解剖结构和手术器械进行显示和定位,制定手术计划,模拟手术操作,术中追踪显示手术器械,引导手术进程,利用计算机和机器人完成精确、安全、微创的手术操作,使得临床治疗中 PPSF 置钉的准确性不断提高[39-41]。有学者在此基础上,运用激光十字准星辅助显示 PPSF 在皮肤和骨骼上的进钉点,方便术者根据预定轨迹调整器械[42]。在不久的将来,CAOS 系统将会是自动注册匹配的基于术中真实三维图像的操作技术,可在 PPSF 和其他骨科手术中简化手术操作,缩短手术时间,减少手术创伤,减少放射暴露,缩短手术学习曲线。

3 PPSF 治疗胸腰椎骨折的适应证和禁忌证

PPSF 治疗胸腰椎骨折的适应证和禁忌证并未达成共识。以往大多数学者认为 PPSF 适用于椎体压缩小于 50%、椎管未受累或椎管侵占不超过 30%、且不需做椎管减压的新鲜骨折患者;椎管内明显占位或脊髓神经受损需手术探查以及陈旧性骨折往往被认为是禁忌证。Sebaaly 等[9]认为,按 AO 分型,PPSF 的适应证为椎体压缩小于 50% 或局部后凸角小于 20°,且无神经损伤的 A 型损伤,以及 B1 型损伤;PPSF 的禁忌证为出现神经功能缺陷、B2 型骨折、C 型骨折。Wang 等[18]根据临床经验尝试将适应证扩大,除了纳入 AO 分型为 A1、A2、A3 的骨折外,还纳入了 B1、B2、Cl、C2 型骨折,疗效确切,且未发现明显并发症;但该研究样本量有限,还有待进一步研究。PPSF 作为一种微创治疗方法,虽优势明显但也有局限性,临床应用时应严格掌握其适应证。近年来,有学者在临床将 PPSF 作为老年骨质疏松性骨折椎体成形术或球囊后凸成形术的补充手段[43]。Wang 等[18]运用独特的 ZERO 牵开器实现直接椎管减压,配合 PPSF,并通过小切口完成连杆,对有神经损伤的胸腰椎骨折患者进行治疗,效果满意。

4 PPSF 治疗胸腰椎骨折的并发症

PPSF 治疗胸腰椎骨折的并发症主要包括置钉位置不当、断钉、退钉、断棒、切口浅表感染、大血管或内脏受损、暂时性神经症状、强化剂渗漏等。Zhao 等[44]回顾性分析781 例行 PPSF 治疗的胸腰椎骨折患者的临床资料,结果显示:术中并发症包括导丝断裂 3 例、腹主动脉损伤 1 例、因攻丝扩大椎弓根导致的脑脊液

漏3例;术后早期并发症包括单纯椎弓根内侧壁骨折9例,单纯椎弓根外侧壁骨折6例,椎弓根内、外侧壁骨折2例,以及复位不良4例;术后晚期并发症包括螺钉断裂8例,螺钉脱落2例,连接棒松动3例,术后9~12个月出现晚期深部感染5例。导丝断裂可能是由于螺钉与导丝存在一定角度,在向前驱动螺钉时导丝被截断,此外,导丝重复使用也可能引起断裂;腹主动脉损伤、脑脊液漏以及椎弓根骨折可能与螺钉位置调整过程中操作失误有关;术后复位不良主要与后部韧带复合体损伤及多轴螺钉的撑开和复位作用有限有关;螺钉断裂、螺钉脱落及连接棒松动主要与内固定物承受生物应力较大和置钉位置不正确有关;晚期感染主要与患者基础情况有关,如患有糖尿病等。最常见的并发症是螺钉位置不当和感染。Sun 等[17]经过Meta分析发现,经皮椎弓根螺钉与开放椎弓根螺钉的置钉不当率无显著性差异(3.0% *vs.* 5.1%),经皮椎弓根螺钉的感染率明显低于开放椎弓根螺钉(0.4% *vs.* 3.5%)。近年来,由于依赖透视而缺乏直观解剖标志,PPSF导致的颅侧小关节突关节损伤越来越引起人们的重视[45]。从理论上讲,内固定物侵犯关节突关节,在术后持续活动中可能导致关节突的加速退变和邻近节段的过早改变。Lu 等[46]对97例单节段神经系统完整的胸腰椎骨折患者行PPSF,结果发现与常规透视组相比,O型臂导航组在所有节段上均明显降低了关节突损伤率(2.3% *vs.* 11.1%),因此在PPSF过程中导航技术的使用可以明显减少关节突关节的侵犯,有助于防止相邻节段退行性病变的发展。

5 小结与展望

胸腰椎骨折手术治疗的目的是重建脊柱正常解剖结构,恢复脊柱稳定性,解除神经压迫,防止晚期胸腰段畸形和继发的神经损害,为神经功能的恢复提供力学保障。相较于开放手术,PPSF医源性损伤小,术后恢复快,感染率低,固定可靠,矫形效果相当。但作为微创手术,PPSF也有其缺点,包括陡峭的学习曲线、独特的并发症、学习期间过度延长的手术时间、额外的手术设备和费用,同时,PPSF比传统开放手术更依赖术中透视或导航,存在放射暴露问题。PPSF的关键在于进针点和进针角度的确定,但是解剖结构的变异或显像模糊不清可能引起进针点定位困难,而且术中部分医师过度依赖进针的手感来调整角度,会导致学习曲线长,精准度不理想。CAOS技术在脊柱外科中的应用日益广泛,即使解剖变异大、个体差异明显、解剖学标志不明显,CAOS技术仍能将置钉不当发生率降至最低。因此,我们有理由相信,未来PPSF治疗胸腰椎骨折将会更准确、更安全,在个性化、微创化、精准化的征途中不断进步。

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·综 述·

颞叶底部的静脉分布及手术意义

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[摘 要] 颞叶底部静脉分布复杂,其解剖及临床相关研究均较为零散,偶尔承担着重要引流作用的一些静脉结构在不同的文献中称谓各异(如蝶岩窦、蝶岩静脉等),这使得该部位的静脉识别和术中静脉损伤的风险评估较为困难。本文通过对相关文献进行学习,从解剖、影像、手术入路以及静脉性并发症等方面对颞叶底部静脉进行系统阐述,以期为临床工作提供参考。

[关键词] 颞叶底部;静脉;解剖;手术

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Distribution of veins at the temporal base and its surgical significance

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Abstract: Objective The distribution of veins at the temporal base are complex, and the correlational anatomical and clinical studies are sporadic. Some veins that occasionally play an important role in drainage are variously named in literatures (sphenopetrosal sinus/vein, etc), which makes it difficult to identify veins in this area and to assess the risk of intraoperative vein injury. In this paper, the relevant literature were reviewed and systematically analyzed in terms of anatomy, imaging, surgical approach and venous complications of the veins at the temporal base, so as to provide reference for the clinical work.

Keywords: temporal base; vein; anatomy; surgery

颞叶底部静脉分布复杂,经此部位手术时,外科医师较为熟悉并严格保护的是大脑中浅静脉(superficial middle cerebral vein, SMCV)、Labbé静脉,但对于其他的静脉结构认识较少,术前的静脉评估不充分可能会给手术带来一定的难度及风险。大多数情况下,牺牲影响手术进程的术区小静脉或硬脑膜静脉窦,可以明显降低手术难度,且不一定会带来明显并发症[1]。然而,通过前期临床工作中对该区域静脉的观察与研究,我们逐渐认识到需要对颞叶底部静脉损伤予以关注。对于部分患者来说,如手术侧半球表面Trolard静脉和Labbé静脉同时缺如,而同侧SMCV由颞底硬脑膜间引流入后方横窦时,若未在术前静脉成像检查中充分认识到颞底硬脑膜内的静脉窦承担着重要引流作用,损伤了这个在以往手术中看似不重要的静脉结构,

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