

椎间隙高度在颈前路融合术中的研究进展

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【摘要】 颈前路融合术是国内外脊柱外科工作者在手术治疗颈椎疾病的首选方式, 其治疗颈椎退行性疾病、创伤及肿瘤等各种颈椎疾病的效果显著。颈椎前路融合术中需要使用撑开器对患椎间隙进行适当撑开, 以充分暴露、解除致压因素, 恢复病变节段的生理高度、曲度及稳定性, 达到最佳的手术效果, 但目前对于颈椎前路手术中患椎间隙的标准撑开高度尚无共识。本文将从椎间隙高度与颈椎间盘退变机制关系、术中椎间隙高度选择及椎间隙高度与术后效果等 3 个维度对椎间隙高度在颈前路融合术中的研究进展进行综述, 以期对脊柱外科医师在术中行椎间隙撑开时提供理论依据及参考。

【关键词】 颈椎; 椎间隙高度; 脊柱融合术; 综述

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ABSTRACT Anterior cervical fusion surgery is the first choice for spine surgeons in the treatment of cervical spine diseases. It has significant effects in treating cervical degenerative diseases, trauma and tumors and other cervical diseases. In anterior cervical fusion, it is necessary to use a distractor to properly distract the intervertebral space, so as to fully expose and relieve the compressive factors, restore the physiological height, curvature and stability of the lesion segment, and achieve the best surgical effect. However, there is currently no consensus on the standard distraction height for the intervertebral space during anterior cervical surgery. This article reviewed the progress of intervertebral space height in anterior cervical fusion from three dimensions: the relationship between intervertebral space height and cervical disc degeneration mechanism, the selection of intervertebral space height during operation, the recovery of intervertebral space height and the postoperative effect, so as to provide theoretical basis and reference for spinal surgeons when performing intervertebral distraction during operation.

KEYWORDS Cervical vertebrae; Intervertebral space height; Spinal fusion; Review

随着计算机技术不断的深入改变生活及工作方式, 颈椎病的发病趋势不断年轻化, 颈椎病患者人数也在不断攀升^[1], 颈椎病已经对于生活质量产生了严重影响^[2-3]。严重的颈椎病不得不通过手术来解除神经、脊髓的压迫因素, 而手术势必会造成颈椎结构内外负荷异常, 导致颈椎生物力学的平衡失调、影响颈椎前柱维持正常力学的功能。为重建脊柱的稳定性, 脊柱外科医师创造了一类通过融合病变节段以达到平衡力学和重建稳定的手术方式。目前临床以颈前路间盘切除减压植骨融合内固定术(anterior cervical discectomy and fusion, ACDF) 和颈前路椎体次全切减压植骨融合内固定术(anterior cervical corpectomy with fusion, ACCF) 为主要术式, 其有效性及安全性得到普遍认可^[4-7]。近年来的临床实践发现,

ACDF 术后可能发生诸如植骨块脱落、邻近节段退变等并发症, 这在一定程度上影响治疗效果^[8-9], 而 ACCF 术中钛网植骨也有一定的缺陷, 其中钛网沉降对治疗效果影响最大, 文献报道其发生率处于 0%~30%, 钛网沉降可对患者造成不可预估的后果, 甚至需要即刻行脊髓、神经根的再次减压手术^[10-11], 国内外诸多学者探讨过钛网下沉的原因及影响因素, 但意见不一^[10, 12-15]。重建前柱高度, 恢复颈椎生理曲度是颈椎前路手术的重要目的, 但由于椎体是硬性骨质结构, 所以包括椎间盘在内的椎间隙高度是术中的主要变量, 故上述并发症的发生可能与椎间隙高度的改变有很大关系。颈前路融合术中椎间隙的合适撑开是充分减压、曲度恢复的前提, 但目前对于术中椎间隙高度的控制全凭主刀医师的经验, 对于具体撑开高度尚无统一共识。

1 颈椎间盘退变机制与椎间隙变化

椎间盘是一种特殊的结缔组织, 其主要作用是

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连接相邻椎体,为脊柱提供微动,并吸收振荡传导、抵抗拉力和扭转力^[16]。并支持颈椎完成屈伸、侧屈、旋转功能,颈椎间盘的生理高度对于颈椎生物力学平衡机制及灵活性非常重要。椎间盘退变可直接影响椎间隙高度的维持,其退变机制目前仍不明确,但已有研究发现椎间盘蛋白多糖、胶原纤维及胶原交联含量异常会导致髓核脱水、组织纤维化^[17-19],进而髓核与纤维环界限模糊,发生椎间盘退变。颈椎间盘退行性变主要表现为椎间盘体积变小、组织含水量下降,椎间隙边缘骨赘形成,椎间隙高度丢失,椎间盘突出等^[20]。椎间隙高度的变化即为椎间盘高度的改变,椎间高度的下降提示了椎间盘病变^[21]。颈前路术中恢复椎间隙高度是评价手术疗效的重要指标。既往已有临床研究报道,由于没有恢复合理的椎间高度和颈椎曲度,减压不充分导致神经症状持续存在,故椎间隙高度的恢复和颈椎曲度的重建对颈前路手术疗效非常重要。

2 术中椎间隙适当高度选择

颈前路减压融合术中合适的椎间撑开高度有助于改善预后^[22-26],椎间隙高度维持不当,过高或过低均影响手术疗效。椎间隙高度恢复过小,无法完全纠正颈椎曲度,导致颈椎力学失衡,影响术后效果;椎间隙高度恢复过大,术中撑开难度增大,邻椎终板及内置物应力过大,易致椎体骨折、置入物不稳等,加速椎间隙高度的丢失。自融合术开展以来,国内外众多脊柱外科医师对于术中手术节段适合的椎间隙高度做了大量的研究,且各自认为最合适的椎间高度均有差异。起初 Robinson 等^[27]认为合适的椎间隙撑开为 10~15 mm; White 等^[28]认为在颈前路手术中合适的椎间隙撑开为 4~5 mm; Rothman 等^[29]认为在颈前路手术中理想的椎间隙撑开为 7 mm; 也有学者认为在原椎间高度上再撑开 1~2 mm 是术中最佳椎间高度^[30-31],但上述推荐高度未取得生物力学实验的支持。An 等^[32]提出当颈椎间盘高度处于 3.5~6 mm 时,内置物高度应高于此高度 2 mm; 若间盘高度不足 2 mm 或者高于 7 mm, 则应当适当增高或者降低内植物高度。Louis 等^[33]也认为内植物的高度应至少高于原颈椎间盘 2 mm, 达到此高度更能体现良好的手术效果。

徐建伟等^[34]认为术后颈椎前柱高度的改变可直接影响手术效果,当椎间隙撑开恢复至生理高度时,若再行椎间撑开则扭力剧增,可能会导致由于椎体应力过大、后方韧带张力增加而出现神经、脊髓等软组织的应激反应,不利于手术疗效。部分学者提出术中最佳椎间高度应参照基准高度而定,其中殷德振等^[35]通过椎体模型实验,比照基准椎体高度,当撑开

高度达到 140% 基准高度以上时,目标节段的稳定性显著增加; 140%~160% 时,植骨的力学稳定性最佳。Lu 等^[36]提出在 C_{5,6} 椎间植骨时,基准高度的 120% 是最符合颈椎力学稳定性的高度,此结论与罗春山等^[37]利用大体标本模型进行的生物力学试验所得出的结论一致。王海波等^[38]则提出患椎间隙的恢复高度应参照健康椎间隙的高度而定,认为术中患椎间隙撑开后的高度与自身正常椎间隙高度的比值在 95% 内时手术效果较为满意。陆廷盛等^[39]分析了临床术中椎间撑开高度对于颈椎前路融合术后效果的影响,其按术中撑开基础高度的值将病例分为原位组(100%~110%)、适度撑开组(110%~130%)、过度撑开组(>130%),发现术后 2 年适度撑开组的日本骨科协会(Japanese Orthopaedic Association, JOA)评分和影像学表现均优于其他两组,故提出颈前路融合术中的椎间撑开高度应在 110%~130%。

3 术中恢复椎间隙高度与术后效果

3.1 术后邻椎退变

颈椎病邻近节段的退变在临床中比较常见,国外统计颈椎术后邻椎退变发病率约为 3%^[40]。对于已经手术融合或先天融合节段的邻近间盘而言,由于生物力学的改变,其颈椎邻椎病的发生率也会显著上升^[41]。关于颈前路融合术后邻椎病的发病机制仍在不断深入研究中,有学者认为术中椎间隙撑开高度的不合理导致术后颈椎椎间隙高度恢复的不当、颈椎曲度发生改变是邻椎病发生的重要因素^[42]。颈椎退变疾病的手术治疗目标之一是恢复患椎椎间隙的正常高度,颈前路融合术后治疗节段的椎间活动基本缺失,其邻近节段的应力代偿性增大,所以术中若没有恢复良好的椎间隙高度,会影响邻近节段的力学改变,加速邻近节段退变、邻椎病发生^[43]。Li 等^[25]对既往病例回顾性研究发现,当颈椎椎间隙撑开过高时,其邻椎病发生率显著高于未撑开组,原因可能是由于撑开后所植融合骨块过大而增大邻椎的应力改变,增加了邻椎病的发生率,然而如果不行椎间撑开,则神经、脊髓减压可能不彻底,术后颈部轴性症状的发生率也会提高。徐锦明等^[44]回顾性研究了 ACDF 术中不同椎间隙撑开高度的临床病例,认为椎间撑开高度是影响术后邻椎退变发生率的原因之一,并提出术中患椎间隙撑开高度应在 2~4 mm。

3.2 术后轴性症状

轴性症状(axial symptom, AS)是颈椎手术常见并发症,通常发生于颈后路手术中,颈前路较少发生。但相关文献报道其发生率达 5.2%~61.5%^[45],主要表现为颈肩部主观疼痛和自觉僵硬^[46]。AS 的发病机制与多种因素有关,比如肌肉疾患、颈椎矢状位失

衡、颈椎术中椎间隙撑开高度不当及椎间盘、韧带原有疾病等^[25,47-50]。周玉军等^[51]对 113 例行颈椎前路融合术的患者进行术后 12 个月的随访,探讨融合术椎间隙撑开高度与 AS 发生率的关系,结果发现术中椎间隙撑开过大或过小均易导致术后 AS 产生,认为患椎间隙最适撑开高度为 2~4 mm。Wang 等^[52]回顾性研究了单节段颈前路椎间盘切除融合术后 AS 的危险因素,提出椎间隙扩大是 AS 的危险因素,椎间隙过大或者不足均会增加 AS 的发生率。Benaro 等^[53]在以 3 mm 为术中椎间隙撑开标准线进行统计时,发现椎间隙撑开在 3 mm 内有利于维持颈椎生理曲度,并能降低术后轴性症状发生率。王海波等^[38]以健康人的 C_{2,3} 椎间隙高度作为健康椎间隙高度分析 ACDF 术中椎间隙高度与术后疗效关系,术中应尽量使患椎间隙撑开后的高度与自身正常椎间隙高度的比值在 95% 内,术中椎间隙撑开过大或不足均增大术后 AS 发生率。目前关于颈椎前路融合术后轴性症状的研究仍较少,但术中椎间隙撑开高度仍是轴性症状发病机制的重要因素。

3.3 术后神经症状

椎间孔是神经和血管进入脊柱的通道,椎间隙高度丢失则引起椎间孔面积变小,压迫、刺激走行其中的脊神经根、血管,产生相应的临床症状。颈前路手术中适当撑开椎间隙可以在一定程度上拉直因椎间高度丢失引起褶皱的黄韧带,从而增大椎管容积及椎间孔面积,减轻神经症状。有研究表明椎间隙撑开不足或者过大,均会影响术后神经功能的恢复^[54]。

早期学者张正丰等^[55]以大体标本探究椎间隙撑开高度与椎间孔面积改变关系,数据表明,当椎间隙被撑开 2~3 mm 时,椎间孔面积显著增大,因此他们认为在行颈椎前路融合术时,植骨高度应高于椎间盘 2~3 mm; Caspar 等^[30]同样发现当撑开后椎间高度大于原椎间高度 2~3 mm 时,椎间孔的面积能够增大,同时椎间植骨块的载力复核相对较低,临床并发症也较少。而 An 等^[32]通过对尸体标本模拟间盘切除减压、椎间隙撑开时,发现椎间隙撑开高度 > 3 mm 时椎间孔的面积不会明显增大。王良意等^[56]研究报道显示,当椎间隙撑开高度过高,且高度 > 6 mm 时,不但不会提高手术疗效,反而会影响脊髓型颈椎病患者术后神经功能的改善,部分患者可能会加重。朱媛君等^[57]通过建立有限元模型进行研究,发现当椎间隙撑开过高或植骨块过大时,容易导致椎间孔的狭窄,从而引起神经根受压、受损表现。综合以上关于撑开高与椎间孔面积关系的研究,我们可以得到启示:临床实践中不仅要考虑撑开高度的大小,还要结合患者手术节段的原有椎间隙及邻椎间隙高度情

况综合考虑,否则可能会影响手术的效果及预后。

3.4 术后曲度与稳定性

术中合适的椎间隙撑开是维持术后颈椎曲度及稳定性的重要因素,撑开过小无法恢复曲度、重建稳定性,过大则改变原生理曲度,造成颈椎不稳。在颈椎椎间隙不同程度撑开的时候,颈椎的肌肉、韧带、关节囊等颈椎动力稳定系统也会出现相应的变化,影响着术后颈椎生物力学的重建,最终影响颈椎的稳定性。颈椎的整体稳定性对于脊髓、神经功能十分重要^[58]。适合的颈椎椎间隙撑开高度对于恢复颈椎的生理曲度、增大椎间孔面积、恢复周围软组织的平衡、稳定术后疗效、降低并发症的发生等具有重要的临床意义^[59]。

Lee 等^[60]认为颈椎生理曲度是影响邻近节段退变 (adjacent segment degeneration, ASD) 发生率的重要因素。曾腾辉等^[61]用羊颈椎进行了不同高度椎间融合器对颈椎生物力学影响的生物力学实验,术中植入 3~6 mm 不同高度颈前路椎间融合器,结果发现 3 mm 椎间融合器置入时颈椎生物力学稳定性较好。殷德振等^[35]通过尸体标本研究发现在 140% 或 160% 基准高度下行椎间植骨,脊柱的稳定性最佳,但 160% 的基准高度下植骨可能会增加手术的难度,延长手术时间,同时植骨块过高会导致局部应力增大,出现植骨块骨折、移位、终板受损的可能性增加,术后也可能导致邻近椎体退变加速、颈部轴性症状的发生,因此推荐 120% 的基准高度下植骨,罗春山等^[62]研究结果与之相似。Lu 等^[36]在进行模拟 C_{5,6} 不同高度椎间植骨时,发现植骨高度是基准高度的 120% 时颈椎活动度最佳,最符合颈椎力学稳定性。此外,研究发现,即使椎间隙撑开高度相同,椎间盘切除术和椎体次全切除术,颈椎即刻的稳定性也不一样^[63]。Alhashash 等^[42]对 70 例行颈椎融合术的患者行长期随访研究发现,术中曲度恢复不佳的患者更可能发生 ASD,特别是邻近节段本就有退变征象的患者。

4 总结与展望

颈前路术中椎间隙理想的撑开高度既要充分达到临床减压效果,还要做到远期疗效满意。然而目前对于合适的椎间隙撑开高度仍没有统一的观点,也缺乏多中心的研究。合适的椎间高度应在术前综合评估患者影像检查及临床症状体征等,并根据术中的实际情况决定,颈前路融合术中患椎间隙高度的撑开在术中是极其重要的一步,但由于伦理等限制,无法做到在体的实验研究,而大体标本的数据又与临床患者有很大差距。因此,寻找一种进行撑开高度与颈椎生物力学关系的可靠的离体研究手段,比如

三维有限元法, 或者开发一种术中力学实时测试设备可能是下一步的研究方向。笔者相信, 随着医疗技术的进一步发展、多学科的交叉融合, 肯定会在此领域取得长足的进步。

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