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不同容量胸段经椎间孔硬膜外注射阻滞范围的CT影像研究及诊断性阻滞的可行性分析*

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摘要 目的：探讨不同容量对胸段经椎间孔硬膜外注射（TFEI）药液扩散范围和镇痛效果的影响以及胸段TFEI用于诊断性阻滞的可行性。**方法：**选择2021年1月至2022年12月南京大学医学院附属鼓楼医院收治的胸段带状疱疹相关疼痛患者140例，随机分为4组，实施单次TFEI并分别注入不同容量含造影剂局麻药（A组：0.2 mL；B组：0.5 mL；C组：1.0 mL；D组：2 mL），CT扫描并观察造影剂在硬膜外向头侧、尾侧及总扩散节段，造影剂在椎间孔、同侧椎旁间隙、同侧及对侧硬膜外间隙扩散情况，判断是否为选择性神经根阻滞。评估注射前、注射后30分钟及24小时视觉模拟评分（VAS）。**结果：**头侧和尾侧扩散节段以及总扩散节段数，D组最多，A组最少（$P<0.05$）；C组、D组造影剂扩散≥3个节段发生率明显高于B组（$P<0.05$）；C组、D组病例造影剂扩散至同侧椎旁间隙和对侧硬膜外间隙的发生率明显高于A组、B组（$P<0.05$），仅A组37.1%的病例实现选择性神经根阻滞，其余各组均无选择性阻滞病例。注射后30分钟，C、D组VAS评分显著低于A、B组（$P<0.05$）；注射后24小时，D组VAS评分显著低于A、B组（$P<0.05$）。**结论：**胸段带状疱疹相关疼痛患者TFEI药液扩散范围随注射容量的增加而扩大，且在硬膜外倾向于头侧扩散，2 mL容量单次TFEI可阻滞3个以上的神经节段，获得良好的镇痛效果。胸段TFEI行诊断性阻滞的可行性较差。

关键词：经椎间孔硬膜外注射；CT；镇痛；胸段带状疱疹相关疼痛；诊断性阻滞

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CT Imaging Study of the Range of Block Transforaminal Epidural Injection Through Intervertebral Foramen in Different Volume Thoracic Segments and Feasibility Analysis of Diagnostic Block*

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ABSTRACT Objective: To explore the influence of different volume on the diffusion range and analgesic effect of transforaminal epidural injection (TFEI) through intervertebral foramen of thoracic segments and the feasibility of thoracic TFEI for diagnostic block. **Methods:** From January 2021 to December 2022, 140 patients with thoracic zoster associated pain who were admitted to Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University were selected, they were randomly divided into 4 groups, they were given a single TFEI and injected with different volumes of local anesthetics containing contrast agents (group A: 0.2 mL. Group B: 0.5 mL. Group C: 1.0 mL. Group D: 2 mL), CT scan was performed to observe contrast agent diffusion in the outward-dural cephalic, caudal and total diffusion segments, and contrast agent diffusion in the foramina, ipsilateral paravertebral space, ipsilateral and contralateral epidural space, to determine whether it was selective nerve root block. The visual analogue scale (VAS) was evaluated before injection, 30 minutes after injection and 24 hours after injection. **Results:** The number of cephalic and caudal diffusion segments and total diffusion segments was the highest in the group D, and the lowest in the group A ($P<0.05$). The incidence of contrast agent diffusion greater than or equal to 3 segments in the group C and D were significantly higher than that in the group B($P<0.05$). The incidence of contrast media diffusion into the ipsilateral paravertebral space and contralateral epidural space in the group C and group D were significantly higher than that in the group A and group B ($P<0.05$). Only 37.1% of patients in the group A achieved selective nerve root block, and no cases of selective block were found in other groups. At 30 minutes after injection, the VAS score in the group C and D were significantly lower than that in the group A and B ($P<0.05$). At 24 hours after injection, the VAS score in the group D was significantly lower than that in the group A and B ($P<0.05$). **Conclusions:** In patients with thoracic zoster associated pain, the diffusion range of TFEI solution expands with

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the increase of injection volume, and tends to be cephalic diffusion in the epidural space. A single TFEI with 2 mL volume can block more than 3 nerve segments and obtain good analgesic effect. The diagnostic block of thoracic TFEI is not feasible.

Key words: Transforaminal epidural injection; CT; Analgesic; Thoracic zoster associated pain; Diagnostic block

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前言

经椎间孔硬膜外注射(TFEI)是一项常用的临床技术,可以将药物注入硬膜外间隙实现对病变部位的浸润,广泛用于治疗带状疱疹、带状疱疹后神经痛以及其他多种胸背部慢性疼痛疾病[1-3]。尽管 TFEI 有着较长的应用历史,临床实施胸段 TFEI 时的容量选择仍然依靠医师的经验与习惯。带状疱疹相关疼痛通常仅表现为 1-3 节段皮区疼痛, 但临床中往往选择较大容量(5 mL)的药物进行 TFEI 注射[4,5]或多节段同时注射[6]。大容量注射可能导致广泛的硬膜外阻滞,对于高龄患者易出现低血压等并发症,大容量药物还增加了局麻药物中毒、血管栓塞等风险,多节段同时穿刺注射也增加了穿刺损伤及注射相关并发症的发生风险[7]。关于 TFEI 注射治疗胸背部慢性疼痛的容量选择仍缺乏相关的文献报道,对于不同的治疗节段和范围,如何选择对应的注射容量,值得深入研究。本研究探讨了不同容量对胸段 TFEI 浸润范围和镇痛效果的影响,评估胸段 TFEI 用于诊断性阻滞的可行性, 为临床实施治疗性及诊断性 TFEI 提供容量选择的依据。

1 资料与方法

1.1 一般资料

选择 2021 年 1 月至 2022 年 12 月南京大学医学院附属鼓楼医院收治的胸段带状疱疹相关疼痛患者 140 例,入组患者采用随机数字表法分为 4 组(A 组 35 例、B 组 36 例、C 组 35 例; D 组 34 例),行疱疹主要侵犯神经节段的 TFEI,分别注射不同容量含造影剂局麻药,行 CT 扫描观察造影剂扩散范围。本研究已获南京大学医学院附属鼓楼医院医学伦理委员会批准,注射治疗前与患者签署知情同意书。纳入标准:(1)胸段带状疱疹相关疼痛患者(T1-12);(2)住院期间拟行经椎间孔硬膜外药物注射;(3)年龄 >18 岁。排除标准:(1)造影剂(碘海醇注射液)或局麻药过敏;(2)脊柱畸形、脊柱手术、外伤、肿瘤等引起胸椎正常结构异常;(3)凝血功能障碍、穿刺处感染等治疗禁忌;(4)孕妇;(5)认知功能障碍等因素不能完成疼痛评估。入组患者一般资料如表 1 所示。

表 1 各组患者的一般资料

Table 1 General information of patients in each group

General information	Group A(n=35)	Group B(n=36)	Group C(n=35)	Group D(n=34)	F/x^2	*P*
Gender(male/female)	25/10	24/12	22/13	22/12	0.639	0.888
Age(years)	62.3± 10.2	65.1± 9.9	66.1± 11.3	65.0± 11.0	0.986	0.401
BMI(kg/m^2)	24.4± 2.6	23.1± 2.6	23.3± 3.2	23.9± 3.1	1.370	0.255
Course of disease(months)	4.6± 3.8	4.8± 4.2	4.8± 3.4	5.0± 4.1	0.053	0.984
Side classification(left: right)	16:19	12:24	15:20	14:20	1.245	0.742
VAS scores(scores)	5.3± 0.8	4.9± 0.8	5.1± 0.9	5.1± 0.9	1.669	0.177
Range of injection segment					3.139	0.791
Upper thoracic segment(T1-4)	12	15	15	12		
Middle thoracic segment(T5-8)	10	9	12	13		
Lower thoracic segment(T9-12)	13	12	8	9		

1.2 方法

入组患者接受 TFEI 注射不同容量的含造影剂局麻药,A 组:0.2 mL;B 组:0.5 mL;C 组:1.0 mL;D 组:2 mL。注射药物以造影剂(碘海醇注射液,300 mgI/mL,通用电气药业(上海)有限公司)与 0.75%罗哌卡因 1:1 混合。所有穿刺注射过程由同一名医师完成。患者入室,取俯卧位,胸下垫枕,确定疱疹主要侵犯神经节段为目标注射节段, 脊椎旁放置含铅定位网格, 行 CT 扫描(16 排,Brilliance TM CT, Phillip),层厚 2 mm,断层图像定位胸椎间孔头侧 1/2,背侧 1/2 为穿刺目标,设计穿刺路径(图 1A),标记皮肤穿刺点。常规手术区域皮肤消毒,铺巾,1%利多卡因局部麻醉,取 21G 穿刺针,按设计穿刺路径刺入皮肤,在 CT 引导下穿刺至椎间孔目标位置(图 1B、C)。回抽无血、无气、无液,根据不同的分组,注射不同容量含造影剂局麻药溶液,推注速度 0.1 mL/ 秒,注射器推注结束后插入针芯,将针内药液推出。CT 扫描,层厚 2 mm,评估造影剂扩散情况。

1.3 观察指标

1.3.1 矢状位观察造影剂扩散 矢状位根据脊柱椎体终板水平线进行空间划分(图 2A)。判断:(1)头侧扩散节段:如果造影剂头侧到达上一个椎体的下终板水平, 视为到达上一个节段, 头侧扩散节段加 1;(2)尾侧扩散节段:如果造影剂尾侧到达下

一个椎体的上终板水平，视为到达下一个节段，尾侧扩散节段加 1；(3)总扩散节段：药物浸润在注射节段计 1，总扩散节段=1+ 头侧扩散节段 + 尾侧扩散节段。

1.3.2 **横断位观察造影剂扩散** 横断位根据椎间孔外口、硬膜囊同侧外缘、椎管内中线、硬膜囊对侧外缘进行空间划分(图 2B)，判断标准：(1)到达同侧椎间孔：椎间孔外口至同侧硬膜囊外缘(图 2C)；(2)到达同侧硬膜外间隙：同侧硬膜囊外缘至椎管内中线(图 2D)；(3)到达对侧硬膜外间隙：椎管内中线至对侧硬膜囊外缘(图 2E)；(4)到达同侧椎旁间隙：造影剂出同侧椎间孔进入椎旁间隙区域(图 2F)；(5)当造影剂仅局限在同侧椎间孔及同节段椎旁间隙区域，判定为神经根的选择性阻滞。

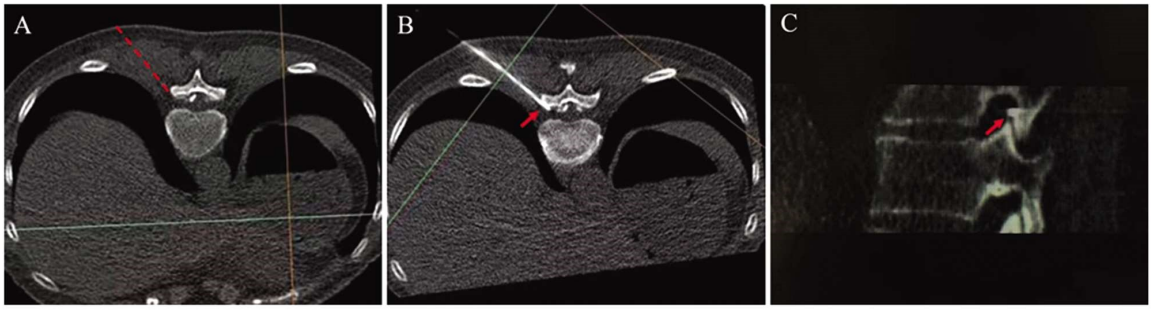

图 1 CT 引导下胸椎间孔穿刺

Fig.1 CT-guided puncture of thoracic intervertebral foramen

Note: A: Plan the puncture path of intervertebral foramen on the horizontal CT image. B: Puncture the needle tip (red arrow) to the dorsal 1/2 part of the intervertebral foramen. C: Puncture the needle tip (red arrow) to the cephalic 1/2 part of the intervertebral foramen.

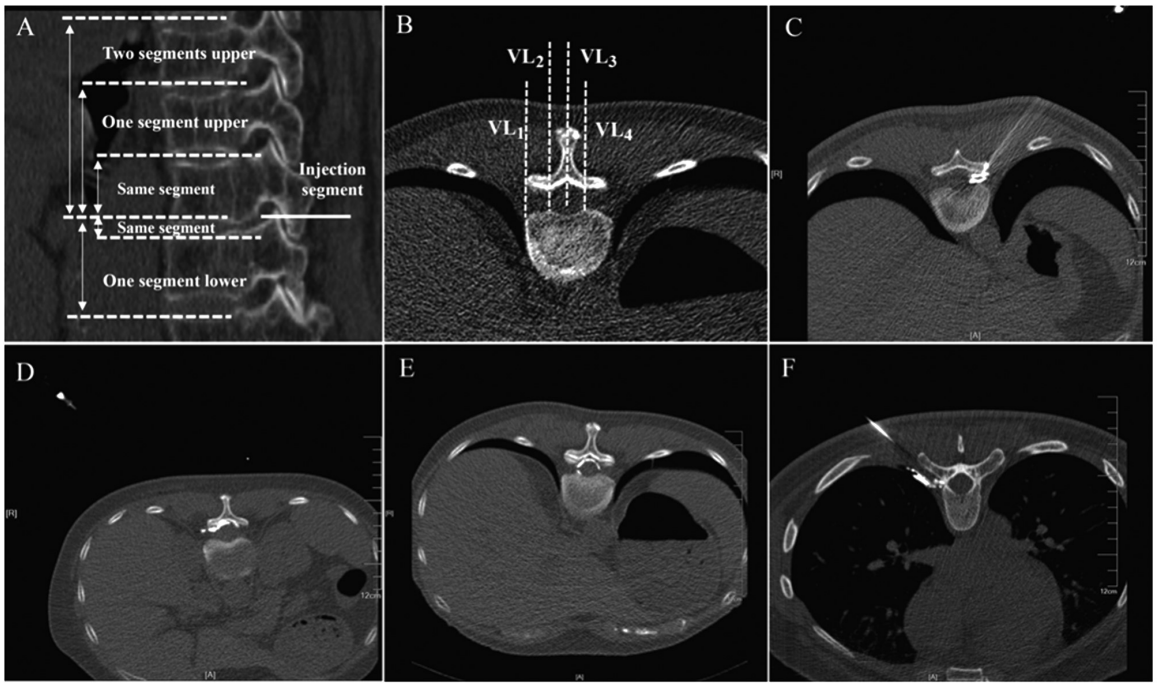

图 2 造影剂扩散范围评估

Fig.2 Assessment of diffusion range of contrast agent

Note: A: In sagittal position, the contrast agent diffusion segment was divided according to the horizontal line of the vertebral endplate. B: The transverse fracture images were spatially divided by the vertical line of the outer opening of the intervertebral foramen (VL1), the vertical line of the outer edge of the ipsilateral dural sac (VL2), the middle line of the spinal canal (VL3), and the vertical line of the outer edge of the contralateral dural sac (VL4). C: Reach the ipsilateral intervertebral foramen. D: Reach the ipsilateral epidural space. E: Reach the opposite epidural space. F: Reach the ipsilateral paravertebral space.

1.3.3 **镇痛效果评估和并发症** 注射前、注射后 30 分钟、24 小时使用视觉模拟评分(VAS)[8]评估患者的疼痛程度。治疗期间观察注射相关并发症，包括气胸、局麻药中毒、严重低血压、血肿、神经损伤、脊髓损伤、感染等。

1.4 **统计学分析**

采用 SPSS 23.0 软件进行统计分析，正态分布的计量资料用均数± 标准差($\bar{x}$± SD)表示，采用方差分析 +LSD-t 检验；非正态分布资料采用中位数 M（P_{25}，P_{75}）表示，组间比较采用 Kruskal-Wallis H 检验。计数资料使用频数(率或百分比)表示，组间比较采用卡方检验，重复测量资料采用重复测量的方差分

析进行组间及组内比较。P<0.05 为差异有统计学意义。

2 结果

2.1 不同容量胸段 TFEI 矢状位水平造影剂扩散情况

矢状位水平观察结果如表 2 所示，头侧、尾侧及总扩散节段、扩散≥3 个节段占比四组间差异存在统计学意义（P<0.05）。头侧、尾侧扩散节段以及总扩散节段数 D 组明显多于 A、B、C 组，B 组、C 组明显多于 A 组（P<0.05）；A 组无病例造影剂扩散≥3 个节段，明显低于 B、C、D 组，C 组、D 组造影剂扩散≥3 个节段发生率明显高于 B 组（P<0.05）。

表 2 不同容量胸段 TFEI 矢状位水平造影剂扩散情况

Table 2 Diffusion of contrast media at sagittal level of thoracic TFEI with different volumes

Contrast agent diffusion	Group A(n=35)	Group B(n=36)	Group C(n=35)	Group D(n=34)	H/x^2	P
Cephalic diffusion segments	0(0, 0)	1(1, 1)[a]	1(1, 2)[a]	2(2, 2)[abc]	96.559	<0.001
Caudal diffusion segments	0(0, 0)	1(0, 1)[a]	1(1, 1)[a]	2(1, 2)[abc]	95.683	<0.001
Total diffusion segments	1(1, 1)	3(2, 3)[a]	3(3, 4)[a]	4(4, 5)[abc]	113.781	<0.001
Diffusion≥3 segments	0	21 (58.3%)[a]	33(94.3%)[ab]	34(100.0%)[ab]	94.445	<0.001

Note: compared with group A, [a]P<0.05. Compared with group B, [b]P<0.05. Compared with group C, [c]P<0.05.

2.2 不同容量胸段 TFEI 横断位水平造影剂扩散情况以及胸段 TFEI 用于诊断性阻滞的可行性

四组所有病例均出现了同侧椎间孔的造影剂扩散；A 组 62.9%的病例造影剂扩散至同侧硬膜外间隙，B、C、D 组所有病例均扩散至同侧硬膜外间隙，明显高于 A 组（P<0.05）；C 组、D 组病例造影剂扩散至同侧椎旁间隙和对侧硬膜外间隙的发生率明显高于 A 组、B 组，B 组造影剂扩散至对侧硬膜外间隙的发生率明显高于 A 组（P<0.05）。横断位水平上观察结果如表 3 所示。

胸段 TFEI 用于诊断性阻滞的可行性：只有 A 组 37.1%（13/35）的病例实现选择性神经根阻滞，其余组均无病例实现选择性神经根阻滞。

表 3 不同容量 TFEI 横断位水平造影剂扩散情况

Table 3 Diffusion of contrast media at transverse section level of TFEI with different volumes

Contrast agent diffusion	Group A(n=35)	Group B(n=36)	Group C(n=35)	Group D(n=34)	x^2	P
Ipsilateral intervertebral foramen	35(100.0%)	36(100.0%)	35(100.0%)	34(100.0%)	-	-
Ipsilateral epidural space	22(62.9%)	36(100.0%)[a]	35(100.0%)[a]	34(100.0%)[a]	32.634	<0.001
Ipsilateral paravertebral space	10(28.6%)	11(30.6%)	26(74.3%)[ab]	29(85.3%)[ab]	36.310	<0.001
Contralateral epidural space	0	7(19.4%)a	30(85.7%)[ab]	34(100%)[ab]	100.293	<0.001

Note: compared with group A, [a]P<0.05. Compared with group B, [b]P<0.05.

2.3 不同容量胸段 TFEI 注射前后 VAS 评分变化以及并发症

如图 3 所示，A-D 组注射后 30 分钟和 24 小时的 VAS 评分呈先下降后升高的趋势，与注射前相比，注射后 30 分钟和 24 小时的 VAS 评分均明显降低（P<0.05）；注射后 30 分钟，C、D 组的 VAS 评分显著低于 A、B 组（P<0.05）；注射后 24 小时，D 组 VAS 评分显著低于 A、B 组，B、C 组显著低于 A 组（P<0.05）。各组均未见明显治疗相关并发症。

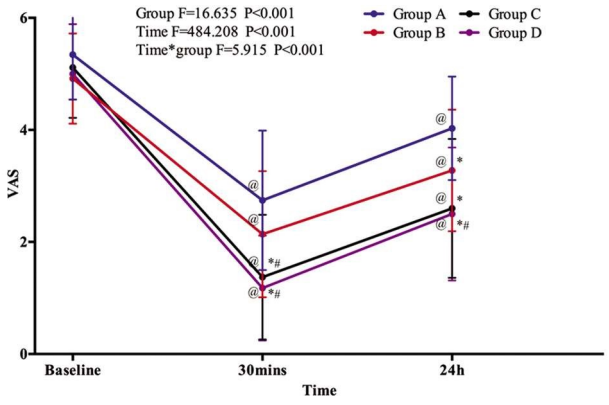

图 3 注射前后各组患者的 VAS 评分变化

Fig.3 VAS score changes of patients in each group before and after injection

Note: compared with group A, *P<0.05. Compared with group B, #P<0.05. Compared with before injection, @P<0.05.

3 讨论

胸段 TFEI 是治疗带状疱疹相关疼痛等慢性疼痛疾病的重要手段[9,10]，随着超声可视化技术的应用，临床实施胸段 TFEI 不再受到 X 线或 CT 影像设备的限制，更为便捷易行，门诊即可开展[11-13]。充分了解不同容量对胸椎 TFEI 药物扩散范围的影响，对临床实施 TFEI 治疗慢性疼痛疾病具有重要的指导意义。糖皮质激素和局麻药物是主要的两种药物，精准控制注射容量可以避免糖皮质激素过多稀释，让更多药物聚集在病变部位，还可以避免大容量局麻药物注射引起广泛的硬膜外阻滞及相关并发症[14,15]。

本研究结果显示随着注射容量的增加，矢状位扩散范围也相应扩大。Hong JH 等[16]的研究表明，经椎间孔注射 1 mL、2 mL、

3 mL 容量药物的总扩散节段中位数为 3,4,6 个节段，其研究结果与本研究相当。容量的大小除了影响矢状位扩散节段,当容量达到 0.5 mL以上时,所有病例注射节段的椎间孔及硬膜外区域均有造影剂扩散,而对于最小的 0.2 mL容量,会有 37.1%的病例造影剂未扩散至同侧硬膜外。由于临床上带状疱疹相关疼痛所在皮区常分布在主要受累节段及头尾侧相邻 1 个节段，即通常要求的阻滞范围需覆盖 3 个节段[17-19],因此,本研究中统计了四组中造影剂扩散≥3 个节段的发生率,结果显示 1 mL和 2 mL容量的发生率超过 90%。尽管所有容量注射后 30 分钟和 24 小时的 VAS 评分较注射前均明显下降，但 1 mL和 2 mL容量的镇痛效果明显更优。综合造影剂扩散≥3 个节段的发生率及注射后的镇痛效果,2 mL容量可满足胸椎 TFEI 治疗带状疱疹相关疼痛的需要,也可能避免更广泛的硬膜外阻滞范围。尽管既往的文献报道中，与腰椎相比胸椎椎管内脂肪组织较少，硬膜与椎管的粘连也较少，胸椎硬膜外药液扩散的阻力更小，更易实现对侧硬膜外的药液浸润[20]。本研究的结果中提示低容量注射时仍有可能出现单侧阻滞，注射 0.2 mL容量和 0.5 mL容量时，造影剂对侧硬膜外间隙的发生率分别为 0 和 19.4%，而将容量增加至 1.0 mL和 2.0 mL时，该发生率逐渐增加至 85.7%和 100%。

对于复杂的脊柱相关疼痛,实施选择性神经根阻滞可以辅助病变部位的定位,提升临床治疗的准确性[21-23]。为了实现诊断选择性神经根阻滞,要求严格控制药物容量,使其尽可能集中在单神经根周围,同时减少对硬膜外组织的浸润。Furman MB 等[24]的研究提示,腰椎 TFEI 注射 0.5 mL药物,约 30%病例不具有神经根选择性,注射 1 mL、1.5 mL和 2.5 mL容量时,约 67%、87%和 90%的病例不具有神经根选择性。有中度证据支持使用小剂量(推荐 0.5 mL)局麻药物实施诊断性腰椎 TFEI,其敏感性为 65%-100%,特异性为 71%-95%[25,26]。本研究观察了 0.2 mL,0.5 mL,1.0 mL和 2.0 mL容量造影剂胸段 TFEI 的分布情况,其中只有 0.2 mL容量有 37.1%的病例可以实现神经根的选择性阻滞,0.5 mL,1.0 mL和 2.0 mL容量 TFEI 的所有病例均无神经根选择性。胸椎椎间孔长度较腰椎小,可能导致了即使是 0.5 mL容量，胸段 TFEI 仍然不具有神经选择性，明显低于腰椎 TFEI,同时,将容量进一步降至 0.2 mL,其选择性阻滞病例也仅占 37.1%,提示了胸段诊断性 TFEI 的可行性较差,临床如需对病变节段进行鉴别,可以考虑肋间神经阻滞等其他方案。

综上所述，胸段带状疱疹相关疼痛患者 TFEI 药液扩散范围随注射容量的增加而扩大,2 mL容量单次 TFEI 可阻滞 3 个以上的神经节段,为带状疱疹相关疼痛的治疗提供良好的镇痛效果,胸段 TFEI 行诊断性阻滞的可行性较差。本研究仍存在局限性:CT 成像造影剂只能一定程度反映真实的药物扩散范围,在药液扩散边缘位置,由于造影剂浓度较低,CT 可能无法清晰显示,但该区域仍可能有一定浓度的局麻药物发挥作用。

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