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电视辅助胸腔镜肺段切除术的发展历程

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摘　要

电视辅助胸腔镜手术(VATS)已逐渐应用于胸外科，现在已经扩展到技术上具有挑战性的手术中，如肺节段切除术及复杂肺段切除术。VATS肺段切除术的定义随着时间的推移而改变，随着低剂量肺部CT (LDCT)筛查的普及，胸腔镜下肺段切除的范围越来越广。VATS肺段切除术具有外科、肿瘤学和技术优势；然而，仍有一些领域，特别是在肿瘤学结果方面存在问题。VATS肺段切除术的适应症多种多样，可适用于临床治疗肺部恶性肿瘤、转移性肺癌或各种病灶较深的非恶性疾病。对于保留肺实质切除深部小结节或同一肺叶多处结节的手术治疗尤其具有重要意义。VATS肺段切除术需要对肺实质解剖结构进行彻底分析，并在手术评估的基础上进行量身定制的术前计划以保证术后患者的快速康复。其中的技术挑战包括术中导航、识别和解剖节段间平面的方法，以及防止术后支气管胸膜瘘等并发症。这篇综述将讨论VATS肺段切除术的现状，重点研究当前适应症和技术以及未来展望。

关键词

电视辅助胸腔镜手术，VATS，肺段切除术

Development of Video-Assisted Thoracoscopic Segmental Pneumonectomy

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Abstract

Video-assisted thoracoscopic surgery (VATS) has gradually been applied to thoracic surgery, and has now expanded to technically challenging operations, such as segmental resection of the lung

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and complex segmental resection of the lung. The definition of VATS pulmonary segment resection changes over time. With the popularization of low-dose lung CT (LDCT) screening, the scope of thoracoscopic pulmonary segment resection is becoming wider and wider. VATS segmental pneumonectomy has advantages in surgery, oncology and technology. However, there are still problems in some areas, especially in oncology results. VATS pulmonary segmental resection has various indications and can be used for clinical treatment of lung cancer, metastatic lung cancer or various non-malignant diseases with deep focus. It is particularly important for the surgical treatment of reserving lung parenchyma and resecting deep small nodules or multiple nodules in the same lung lobe. VATS segmental resection requires a thorough analysis of the anatomical structure of the lung parenchyma and a customized preoperative plan based on the surgical evaluation to ensure the rapid recovery of patients after surgery. The technical challenges include the methods of intraoperative navigation, identification and dissection of the inter-segmental plane, and the prevention of postoperative complications such as bronchopleural fistula. This review will discuss the current situation of VATS segmental pneumonectomy, focusing on the current indications, technologies and future prospects.

Keywords

Video-Assisted Thoracoscopic Surgery, VATS, Segmentectomy

1. 引言

胸腔镜现在广泛用于各级胸部手术，使用胸腔镜的微创手术被称为电视辅助胸腔镜手术(video-assisted thoracic surgery, VATS)。VATS 方法已逐渐扩展应用到技术上具有挑战性的手术，使其能够诊断性或治疗性地根治恶性、转移性或非恶性肺部疾病。VATS 肺段切除术也是早期肺恶性肿瘤或没有资格接受标准肺叶切除术患者的首选方式。在这里，我们回顾了 VATS 肺段切除术的现状，重点是其定义、优点、缺点、适应症和技术方面[1]。

2. 定义

VATS 的定义随着时间的推移而同时发生了变化及其发展，目前对定义的概括仍在继续进行[2] [3]。最初进行手术称为 VATS 的前提是胸腔镜的使用。因此，一种间歇性使用胸腔镜的开放式开胸手术可以被称为 VATS。如今，一种直接或通过胸腔镜观察手术视野的肺部手术被称为“混合 VATS”[4]。相比之下，当今手术主要是通过胸腔镜进行监测观察术中情况时，它被称为“胸腔镜手术”、“完全 VATS”，或简称为“VATS”。因此，“VATS 肺段切除术”目前是指切除单个或多个肺段，通过电视胸腔镜显示手术视野。该手术可以使用不同的胸腔操作口数量；但是，它通常包括肋骨间切口保护器展开的主操作窗。肺段切除术可分为典型和非典型。典型的 VAST 肺段切除术包括左肺上叶节段切除、舌段切除基底节切除术，而非典型肺段切除术包括任何上叶、中叶或基底段[5]。相比之下，非典型肺段切除术在技术上是可行，但仍具有十足的挑战性，临床病例数及相关报导例数依旧十分有限[6] [7]。分类也可以根据节段间的形状进行平面：线性(即，舌段切除术和 S^6 节段切除术)；V 形或 U 形(即右侧 S^1、左侧 S^3 肺段切除术)；或术前三维建模(3D)确定手术方案。

3. 优缺点

3.1. 手术因素

VATS 肺段切除术在手术切除率及术后病理方面至少不低于常规开胸手术或肺叶切除术的肿瘤学结果。从理论上讲，它同时包含 VATS 作为一种微创方法的优势在于较小的皮肤切口没有肋骨扩张导致的术后切口疼痛；以及作为一种解剖性保留肺功能的微创切除术。这些因素可降低术后疼痛，缩短住院时间，保留更多肺功能，提高生活质量。然而，一些研究显示了关于 VATS 入路对术后疼痛[8]或节段切除术对肺功能[9]的优势的边缘或有争议的结果。此外，与肺节段间平面相比，肺实质剥离是术后漏气的一个原因，据报道，可导致胸管再插入率更高。

3.2. 肿瘤因素

关于肿瘤学结果 VATS 肺段切除术与肺叶切除术相比仍有待进一步研究证实。胸腔镜下肺叶手术病变切除率可能更高，尤其是在入选标准或手术技术不充分的情况下。与楔形切除术切除率比较可获得比楔形切除更好的结果，包括更大的手术边缘和更高的生存率[10] [11]。然而，肺段切除术本身的好处依旧未能完全证实的，因为大多数过去的研究评估的有效性为有限的切除术包括楔形切除术和单一肺段切除术。淋巴结的评估是临床医师及肺癌患者关注的一个问题。研究主要集中在不同手术入路和手术过程中淋巴结清扫程度的差异上[12] [13]。当比较开胸术和 VATS 入路时，纵隔淋巴结清扫术在手术质量上是相等的。然而，对于肺门和支气管周围的淋巴结，开胸可以进行更彻底的淋巴结分析，术后病理可显示淋巴结上升率更高[12] [14]。当比较 VATS 肺段切除术和肺叶切除术，切除的淋巴结数量相似[15]。在比较肺段切除和楔形切除时，美国外科医生学会外科肿瘤组 Z4032 试验报道，在 I 期 NSCLC (非小细胞肺癌)患者中，肺段切除比楔形切除存在更高的淋巴结清扫率和更高的淋巴结上升率[10]。然而，肺癌中 VATS 肺段切除术的理想淋巴结清扫方法仍存在争议，目前外科共识是建议采用系统或选择性的节段淋巴结清扫方法[16]。

3.3. 技术因素

VATS 肺段切除术的技术优点包括增强并共享外科领域的可视化。胸腔镜实现了高清和放大成像，允许视觉识别节段间平面。此外，结合红外的技术已经引入了吲哚菁绿(ICG)成像用于段间平面的解剖识别[17]。此外，外科领域的共享可视 VATS 在解剖节段切除术中用途极大，因为基于共同观点的术中讨论与术前计划一样有价值，以防止错误识别解剖标志。VATS 肺段切除术的一个普遍公认的缺点是手术时间长[18]。相关报告的中位时间 VATS 肺段切除术的范围为 2.5 至 3 小时，这比开放肺段切开术花费时间更长[19]。然而，一些报告显示两种手术时长无明显差异。此外，VATS 肺段切除术和 VATS 肺叶切除术在手术时长中也无显著差异[20] [21] [22]。在学习曲线期间，操作时间报告较长。最后也是最重要的，VATS 肺段切除术需要特定的设备(如胸腔镜、监护仪、腔镜手术器械、负压引流和 3D 成像系统)，正在开展 VATS 肺段切除术的医疗机构需要解决这些基础设施和成本问题。

4. VATS 肺段切除术的术前准备

4.1. 术前规划

肺段切除术需要对肺部解剖学的精确理解和量身定制的手术计划。值得注意的是，标记段边界的段间静脉，应该详细检查。参考静脉分支模式的简化模型可以促进肺段解剖学的识别，并有助于外科医生在术前规划方案。然而，仅通过常规 CT 图像很难评估肺部解剖，而术前评估大部分采用并参考三维成

像，它可以实现 3 个肺的 360˚视图。三维成像可以对解剖结构进行直观的展示，因此在胸外科医生中获得了肯定和普及。血管描述精度高，肺动脉检出率大于 95% [23] [24]。此外，三维成像也可用于筛选解剖异常的结构或血管。它对 VATS 肺段切除术特别有帮助，因为对支气管血管解剖结构的空间识别是必要的，特别是对于非典型肺段切除术[25] [26]。此外，虚拟辅助肺绘图(VAL-MAP)技术，它结合了 3D-CT 成像和支气管镜标记，提供了肺表面的几何信息，并可应用于 VATS 肺段切除术。3D 成像技术也可以扩展到进行虚拟肺段切除术[27]。三维成像可以通过测量肿瘤边缘与节段间静脉之间的距离或标记“虚拟安全边缘”来评估手术边缘，定义为肿瘤中心的球体。

4.2. 技术方面

胸腔镜手术切口的数量通常在 1 到 4 个之间，并包括一个主操作口。不同手术中，进入胸腔的皮肤切口长度不同。减少操作口数量的尝试促进了单孔 VATS 肺段切除术的发展，仅通过一个操作口进行。为了进一步避免肋间神经损伤，也有剑突下单门静脉入路的报道[28]。然而减少操作口的数量可能会增加手术的复杂性，手术成功与否也会受到外科医生能力的影响，这是一个重要但难以评估的因素。

4.3. 手术过程

VATS 肺段切除术术前根据影像学检查结果及数字化三维重建图像指定手术方案。规范分离出肺段动脉及静脉，之后分离出段间支气管，结扎后复张肺进行观察，采用通气萎陷法显示肺段之间有明显的界限。循此界限对肺组织使用直线切割器分离。肺段间的小血管应用细丝线结扎后离断。肺创面如有明显漏气时，可用细线缝扎避免漏气。

5. 结论

虽然 VATS 肺段切除术在临床中日渐受欢迎，但其在肺癌中的肿瘤适应征仍有争议，需要长期预后随访的验证。此外，由于肺部磨玻璃结节(GGO)比例的增加，肺癌人群异质性增加，VATS 肺段切除术的指征变得更加复杂。尽管如此，VATS 肺段切除术现在成为外科医生手术经验的必经之路，仍需要不断改进。近年来，术中机器人辅助已被引入胸外科，被称为机器人辅助胸外科(RATS)。尽管 RATS 方法的推广仍然有限，但关于 RATS 肺段切除术的技术方面和手术结果的报导正在增加。与引入 VATS 所引发的争议类似，RATS 还需要应对挑战，如短期和长期利益、肿瘤结果和成本效益[29] [30]。随着 VATS 肺段切除术的普及，未来的争论肯定会转向 VATS 和 RATS 节段切除术的利弊比较上。

参考文献

[1] Masuda, M., Kuwano, H., Okumura, M., *et al*. (2015) Thoracic and Cardiovascular Surgery in Japan during 2013: Annual Report by the Japanese Association for Thoracic Surgery. *General Thoracic and Cardiovascular Surgery*, **63**, 670-701. https://doi.org/10.1007/s11748-015-0590-3

[2] Yim, A.P. (2002) VATS Major Pulmonary Resection Revisited-Controversies, Techniques, and Results. *The Annals of Thoracic Surgery*, **74**, 615-623. https://doi.org/10.1016/S0003-4975(02)03579-8

[3] Rocco, G., Internullo, E., Cassivi, S.D., *et al*. (2008) The Variability of Practice in Minimally Invasive Thoracic Surgery for Pulmonary Resections. *Thoracic Surgery Clinics*, **18**, 235-247. https://doi.org/10.1016/j.thorsurg.2008.06.002

[4] Okada, M., Sakamoto, T., Yuki, T., *et al*. (2005) Hybrid Surgical Approach of Video-Assisted Minithoracotomy for Lung Cancer: Significance of Direct Visualization on Quality of Surgery. *Chest*, **128**, 2696-2701. https://doi.org/10.1378/chest.128.4.2696

[5] Ceppa, D.P., Balderson, S. and D'Amico, T.A. (2011) Technique of Thoracoscopic Basilar Segmentectomy. *Seminars in Thoracic and Cardiovascular Surgery*, **23**, 64-66. https://doi.org/10.1053/j.semtcvs.2011.04.009

[6] Endoh, M., Oizumi, H., Kato, H., *et al*. (2017) Posterior Approach to Thoracoscopic Pulmonary Segmentectomy of the Dorsal Basal Segment: A Single-Institute Retrospective Review. *The Journal of Thoracic and Cardiovascular Surgery*,

154, 1432-1439. https://doi.org/10.1016/j.jtcvs.2017.03.120

[7] Sato, M., Murayama, T. and Nakajima, J. (2016) Techniques of Stapler-Based Navigational Thoracoscopic Segmentectomy Using Virtual Assisted Lung Mapping (VAL-MAP). *Journal of Thoracic Disease*, **8**, S716-S730. https://doi.org/10.21037/jtd.2016.09.56

[8] Rizk, N.P., Ghanie, A., Hsu, M., *et al*. (2014) A Prospective Trial Comparing Pain and Quality of Life Measures after Anatomic Lung Resection Using Thoracoscopy or Thoracotomy. *The Annals of Thoracic Surgery*, **98**, 1160-1166. https://doi.org/10.1016/j.athoracsur.2014.05.028

[9] Deng, B., Cassivi, S.D., de Andrade, M., *et al*. (2014) Clinical Outcomes and Changes in Lung Function after Segmentectomy versus Lobectomy for Lung Cancer Cases. *The Journal of Thoracic and Cardiovascular Surgery*, **148**, 1186-1192.e3. https://doi.org/10.1016/j.jtcvs.2014.03.019

[10] Nakamura, H., Taniguchi, Y., Miwa, K., Adachi, Y., Fujioka, S., Haruki, T., *et al.* (2011) Comparison of the Surgical Outcomes of Thoracoscopic Lobectomy, Segmentectomy, and Wedge Resection for Clinical Stage I Non-Small Cell Lung Cancer. *The Journal of Thoracic and Cardiovascular Surgery*, **59**, 137-141. https://doi.org/10.1055/s-0030-1250377

[11] Nakamura, H., Taniguchi, Y., Miwa, K., *et al*. (2011) Comparison of the Surgical Outcomes of Thoracoscopic Lobectomy, Segmentectomy, and Wedge Resection for Clinical Stage I Non-Small Cell Lung Cancer. *The Journal of Thoracic and Cardiovascular Surgery*, **59**, 137-141. https://doi.org/10.1055/s-0030-1250377

[12] Ramos, R., Girard, P., Masuet, C., *et al*. (2012) Mediastinal Lymph Node Dissection in Early-Stage Non-Small Cell Lung Cancer: Totally Thoracoscopic vs Thoracotomy. *European Journal of Cardio-Thoracic Surgery*, **41**, 1342-1348. https://doi.org/10.1093/ejcts/ezr220

[13] Zhou, H., Tapias, L.F., Gaissert, H.A., *et al*. (2015) Lymph Node Assessment and Impact on Survival in Video-Assisted Thoracoscopic Lobectomy or Segmentectomy. *The Annals of Thoracic Surgery*, **100**, 910-916. https://doi.org/10.1016/j.athoracsur.2015.04.034

[14] Boffa, D.J., Kosinski, A.S., Paul, S., *et al*. (2012) Lymph Node Evaluation by Open or Video-Assisted Approaches in 11,500 Anatomic Lung Cancer Resections. *The Annals of Thoracic Surgery*, **94**, 347-353. https://doi.org/10.1016/j.athoracsur.2012.04.059

[15] Shapiro, M., Weiser, T.S., Wisnivesky, J.P., *et al*. (2009) Thoracoscopic Segmentectomy Compares Favorably with Thoracoscopic Lobectomy for Patients with Small Stage I Lung Cancer. *The Journal of Thoracic and Cardiovascular Surgery*, **137**, 1388-1393. https://doi.org/10.1016/j.jtcvs.2009.02.009

[16] Kent, M., Landreneau, R., Mandrekar, S., *et al*. (2013) Segmentectomy versus Wedge Resection for Non-Small Cell Lung Cancer in High-Risk Operable Patients. *The Annals of Thoracic Surgery*, **96**, 1747-1754. https://doi.org/10.1016/j.athoracsur.2013.05.104

[17] Misaki, N., Chang, S.S., Gotoh, M., *et al*. (2009) A Novel Method for Determining Adjacent Lung Segments with Infrared Thoracoscopy. *The Journal of Thoracic and Cardiovascular Surgery*, **138**, 613-618. https://doi.org/10.1016/j.jtcvs.2009.01.003

[18] Wang, B.Y., Liu, C.C. and Shih, C.S. (2010) Short-Term Results of Thoracoscopic Lobectomy and Segmentectomy for Lung Cancer in Koo Foundation Sun Yat-Sen Cancer Center. *Journal of Thoracic Disease*, **2**, 64-70.

[19] Witte, B., Stenz, C., Vahl, C.F. and Huertgen, M. (2015) Comparative Intention To-Treat Analysis of the Video-Assisted Thoracoscopic Surgery Approach to Pulmonary Segmentectomy for Lung Carcinoma. *Interdisciplinary CardioVascular and Thoracic Surgery*, **21**, 276-283. https://doi.org/10.1093/icvts/ivv143

[20] Yamashita, S., Tokuishi, K., Anami, K., *et al*. (2012) Thoracoscopic Segmentectomy for T1 Classification of Non-Small Cell Lung Cancer: A Single Center Experience. *European Journal of Cardio-Thoracic Surgery*, **42**, 83-88. https://doi.org/10.1093/ejcts/ezr254

[21] Hwang, Y., Kang, C.H., Kim, H.S., *et al*. (2015) Comparison of Thoracoscopic Segmentectomy and Thoracoscopic Lobectomy on the Patients with Non-Small Cell Lung Cancer: A Propensity Score Matching Study. *European Journal of Cardio-Thoracic Surgery*, **48**, 273-278. https://doi.org/10.1093/ejcts/ezu422

[22] Lin, Y., Zheng, W., Zhu, Y., *et al*. (2016) Comparison of Treatment Outcomes between Single-Port Video-Assisted Thora-Coscopic Anatomic Segmentectomy and Lobectomy for Non-Small Cell Lung Cancer of Early-Stage: A Retrospective Observational Study. *Journal of Thoracic Disease*, **8**, 1290-1296. https://doi.org/10.21037/jtd.2016.04.65

[23] Fukuhara, K., Akashi, A., Nakane, S. and Tomita, E. (2008) Preoperative Assessment of the Pulmonary Artery by Three-Dimensional Computed Tomography before Video-Assisted Thoracic Surgery Lobectomy. *European Journal of Cardio-Thoracic Surgery*, **34**, 875-877. https://doi.org/10.1016/j.ejcts.2008.07.014

[24] Nagashima, T., Shimizu, K., Ohtaki, Y., *et al*. (2015) An Analysis of Variations in the Bronchovas Cular Pattern of the Right Upper Lobe Using Three-Dimensional CT Angiography and Bronchography. *General Thoracic and Cardiovascular Surgery*, **63**, 354-360. https://doi.org/10.1007/s11748-015-0531-1

[25] Oizumi, H., Kanauchi, N., Kato, H., *et al*. (2011) Anatomic Thoracoscopic Pulmonary Segmentectomy under 3-Dimensional Multidetector Computed Tomography Simulation: A Report of 52 Consecutive Cases. *The Journal of Thoracic and Cardiovascular Surgery*, **141**, 678-682. https://doi.org/10.1016/j.jtcvs.2010.08.027

[26] Oizumi, H., Endoh, M., Takeda, S., *et al*. (2010) Anatomical Lung Segmentectomy Simulated by Computed Tomographic Angiography. *The Annals of Thoracic Surgery*, **90**, 1382-1383. https://doi.org/10.1016/j.athoracsur.2009.11.062

[27] Saji, H., Inoue, T., Kato, Y., *et al*. (2013) Virtual Segmentectomy Based on High-Quality Three-Dimensional Lung Modelling from Computed Tomography Images. *Interdisciplinary CardioVascular and Thoracic Surgery*, **17**, 227-232. https://doi.org/10.1093/icvts/ivt120

[28] Gonzalez-Rivas, D., Yang, Y., Lei, J., *et al*. (2016) Sub-Xiphoid Uniportal Video-Assisted Thoracoscopic Middle Lobectomy and Anterior Anatomic Segmentectomy (S3). *Journal of Thoracic Disease*, **8**, 540-543. https://doi.org/10.21037/jtd.2016.02.63

[29] Wilson, J.L., Louie, B.E., Cerfolio, R.J., *et al*. (2014) The Prevalence of Nodal Upstaging during Robotic Lung Resection in Early Stage Non-Small Cell Lung Cancer. *The Annals of Thoracic Surgery*, **97**, 1901-1906. https://doi.org/10.1016/j.athoracsur.2014.01.064

[30] Echavarria, M.F., Cheng, A.M., Velez-Cubian, F.O., *et al*. (2016) Comparison of Pulmonary Function Tests and Perioperative Outcomes after Robotic-Assisted Pulmonary Lobectomy vs Segmentectomy. *The American Journal of Surgery*, **212**, 1175-1182. https://doi.org/10.1016/j.amjsurg.2016.09.017