左心房心房扑动射频消融治疗进展

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【摘要】 心房扑动(房扑)是一种大折返性心律失常,与心房颤动关系密切,二者经常共存。导管消融术已成为房扑的一线治疗措施,但随访发现患者消融术后新发房性心律失常比例仍然较高。左心房房扑与典型右心房房扑相比机制更为复杂,常与各种原因导致的左心房纤维化有关,且左心房周围毗邻结构也较复杂,对安全有效地消融造成一定困难。随着高精密度标测系统和消融能量的发展,左心房房扑机制越来越清晰,这为左心房房扑实施有效透壁消融终止房扑提供了依据。

【关键词】 左心房心房扑动;射频消融;三维电解剖标测
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Radiofrequency Catheter Ablation of Left Atrial Flutter

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【Abstract】 Atrial flutter is a common macro-reentrant arrhythmia which is closely related to atrial fibrillation, and they often coexist. Catheter ablation has become the first-line treatment for atrial flutter, but the recurrent rate of atrial arrhythmias remains high after long-term follow-up. Compared with typical right atrial flutter, the mechanism of left atrial flutter is more complicated, which is often related to left atrial fibrosis caused by various reasons. Moreover, the adjacent structures around the left atrium are complex, and how to safely and effectively achieve transmural ablation to terminate atrial flutter has become a problem for electrophysiologists. With the rapid development of 3D high-density electroanatomic mapping systems and ablation energy, the mechanism of left atrial flutter has become more and more clearly understood, and the success rate of left atrial flutter treatment can be further improved.

【Key words】 Left atrial flutter; Radiofrequency ablation; 3D Electroanatomic mapping

心房扑动(房扑)是一种大折返性快速性心律失常,多发生于器质性心脏病及部分无心脏病的患者。临床上发病率低于心房颤动(房颤),但发作时的症状较重,常引起血流动力学障碍,可导致心力衰竭、缺血性脑卒中等严重并发症。随着心内标测和射频消融技术的发展,目前已明确房扑的电生理机制是心房内的大折返,折返环位于右心房或左心房,围绕解剖或功能性的传导阻滞区而形成,因此,房扑分为右心房房扑和左心房房扑。临床上右心房房扑更常见,且射频消融效果佳,患者预后较好。而左心房房扑与左心房纤维化相关,更容易导致各种并发症,且射频消融效果常不理想,预后不佳。现回顾近年左心房房扑的诊断和治疗进展,以期提高临床上对左心房房扑的关注,使更多患者得到最优的治疗。

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1　流行病学特点

房扑与房颤在危险因素上有很大的相关性,心房扩大和纤维化是房扑和房颤共同的病理基础,二者也经常共存[1]。与单纯房颤患者相比,房颤合并房扑的患者症状更显著,生活质量也更差[2]。房扑的发病率随着年龄增长而升高,男女比例约为 2.5∶1[3-4]。

房扑根据机制被分为三尖瓣峡部依赖型房扑(典型房扑)和非三尖瓣峡部依赖型房扑(不典型房扑)。不典型房扑的电生理机制可能是围绕手术瘢痕、心房游离壁功能阻滞线、肺静脉、二尖瓣环等部位形成的折返,约占房扑的 10%。左心房房扑属于不典型房扑中的一种。由于目前开展的各种心脏介入和外科手术越来越多,左心房房扑发病率正在逐渐升高[5]。

2　左心房房扑的临床表现和心电图特点

同房颤一样,房扑可以是阵发性的,也可以是持

续性的。临床表现在很大程度上取决于心室率的快慢，由于 2∶1 的房室传导，心室率通常在 120 ~ 150 次/min 左右，但在某些情况下发生 1∶1 的房室传导时会导致极高的心率，患者将无法耐受，通常需要立即干预。由于失去与心室收缩相协调的有效心房收缩以及快速的心室率可能会导致低血压、心绞痛、心力衰竭、晕厥或心悸，是患者前来就医的主要症状和表现。不同于典型房扑较典型的心电图特点，左心房房扑由于左心房中瘢痕区域的大小和位置以及心肌本身的病变，可在心腔内不同位置出现大小不同的折返环[6]，左心房房扑波还可通过不同的心房间连接传入右心房，造成不同的折返环外心肌激动顺序，因此心电图的 F 波表现多种多样[6-8]。

3　左心房房扑的治疗现状

由于房扑通常症状明显，且对药物治疗反应较差，临床治疗较为棘手。导管消融对于恢复窦性节律，改善左心室功能具有重要作用[9]。既往文献报道，在传统拖带和激动标测方法指导下消融的即刻成功率为 50% ~ 80%[10-11]，随着强生、波科、雅培及 Acutus 等公司陆续研发出高精密度电解剖标测(electroanatomic mapping，EAM)系统和标测导管，并且逐渐被应用于左心房房扑的术中标测，左心房房扑标测成功率和消融手术的即刻成功率为 89% 以上，但长期无房性心律失常发生率仍不理想[12-14]。

4　左心房房扑的标测技术

房扑的标测技术是成功消融的基础。近年房扑标测技术从二维的拖带、激动标测，发展到各种三维 EAM 系统，为准确识别和消融关键峡部提供了更多信息，提高了房扑消融的成功率。

4.1　拖带标测和激动标测

由于左心房房扑的发生机制受到既往外科或者消融手术的影响而复杂多变，正确识别关键峡部对于达到成功消融具有重要意义。传统的方法是在侵入性电生理检查中，利用拖带标测确定左心房房扑的消融靶点。拖带标测是通过程序化电刺激来定位折返环路[15]。但拖带标测在左心房房扑标测中存在不少的局限性[16]，可能造成标测失败。

4.2　三维电解剖系统标测

为了实现更快、更安全、更成功的介入治疗，近年来电生理领域发展迅速，以各种三维 EAM 系统及消融导管发展最为显著。三维 EAM 系统是利用专用的高精度标测导管和特定算法，快速提供包括传导阻滞区、瘢痕区以及缓慢传导区等在内的许多电生理特征，通过颜色等方式描述出复杂的心律失常机制，为患者量身定制个性化的消融策略提供依据，有助于避免无效消融和过度消融导致的心律失常，且可实现几乎零辐射下手术过程。接下来着重介绍近年依赖标测和消融领域治疗左心房房扑的新进展。

4.2.1　CARTO 标测系统和 PentaRay 标测导管

CARTO 3.0 标测系统基于电流和磁场的混合信息，将心内电生理信息与解剖结构结合起来，可进行导管跟踪并绘制出可视化的电解剖图，有助于了解心律失常机制及起源的特殊心内结构。近年来，多种配合模块的开发缩短了手术时间，改善了临床结果，并减少了对透视的需求。目前已广泛应用于多种心律失常标测，特别是在疑难心律失常标测和指导消融方面发挥了巨大优势。

PentaRay 标测导管头端的 20 个电极呈海星型展开，确保了与心肌组织安全、良好的贴靠。5 个分支上每个分支包含 4 个直径为 1 mm 的微小电极，电极呈 2-6-2 mm 间距排列，使得导管头端受到远场干扰更少，信号质量比较清晰。相较于逐点标测，PentaRay 标测导管的 5 个分支形成较大的覆盖面使标测更快速，大幅减少了 X 射线的曝光，同时还能显示瘢痕区、低电压区和复杂碎裂电位等，并且有助于判断线性消融的连续性(是否有漏点)等。

CARTO 3.0 v7 标测系统除了显示激动顺序和电压图外，还可将心动过速周长的局部动作电位时间制作成直方图。通过形成直方图，Adragão 等[17]提出将低电压(0.05 ~ 0.30 mV)、深谷(直方图中相对于最高密度区域的密度点 <20% 的区域)以及持续时间占心动过速周长 10% 以上的低电压谷，作为定义房扑折返环中关键峡部的三联征。对 9 例左心房房扑消融展开术后分析，发现符合三联征的位置与术中顺利终止了房扑的位置相符合。9 例患者经过 3 个月随访后均未复发，为定位关键峡部提供了新思路。

4.2.2　EnSite 标测系统和 HD Grid 标测导管

EnSite3000[18]是第一种非接触式球囊心内膜标测系统，利用在心腔内放置多电极阵列式球囊导管构建激动顺序图。但由于非接触标测的特性，当距离超过 40 mm 或局部电压过低时，常无法记录出该部位的电活动信息。EnSite Precision 标测系统在往代系统中基于阻抗定位的功能之上，通过增加基于磁场的定位数据来完善实时追踪，进一步提高了精度，还能快速、自动地对心律失常进行注释和实现可视化。

HD Grid 标测导管由网状分布的 4 × 4 共 16 个电极组成，电极间距为 3 mm，支持自动高分辨率绘图。Balt 等[19]在治疗 82 例不典型房扑患者标测和消融术中首次通过比较 HD Grid 标测导管和标准十极导管，发现 HD Grid 标测导管可显著提高不典型房扑的消融

成功率和远期疗效。Kapur[20] 在治疗 1 例既往曾行肺静脉隔离的不典型房扑患者过程中，使用 HD Grid 导管在不诱导心律失常的情况下，在高右心房起搏下构建左心房等时延迟激动图，发现了左心房前壁的缓慢传导区域，通过激动标测验证了该点为关键峡部，并顺利消融终止房扑，提出了构建心房等时延迟激动图可作为识别不典型房扑关键峡部的方法。

4.2.3 Rhythmia 标测系统和 Orion 标测导管

Rhythmia 标测系统同样基于阻抗和磁场的数据构建高精密度标测图，与其配套的 Orion 标测导管由网篮状分布的 8 × 8 共 64 个电极构成，因其电极小（0.4 mm）、间距小（2.5 mm）的特点和特殊算法，可快速获取数以千计的局部电图，较好地分辨近/远场信号，更高分辨率显示低电压信号，快速绘制超高精度电解剖图，并且能实时监测射频消融的效果、检测缝隙和确认手术终点[21]。

多篇文献报道[22-24] 支持了 Rhythmia 用于标测瘢痕相关房性心动过速、房颤和房扑的安全性和有效性。Rottner 等[25] 在 74 例肺静脉隔离的房颤消融中直接比较了 Rhythmia 标测与 CARTO 标测后发现，二者在手术时间、肺静脉隔离的即刻成功率、中期无房性心律失常生存率之间无差异，只是 Rhythmia 标测所需的时间稍长。目前尚未有 Rhythmia 标测与 EnSite Precision 标测的直接对比，在一个小规模非随机研究[26] 中发现与 PentaRay 标测导管相比，Orion 标测导管可能会增加术后无症状脑栓塞的发生率。

4.2.4 AcQMap 标测系统和 AcQMap 导管

AcQMap 标测系统是目前较新的标测系统，与其相对应的 AcQMap 导管是一种新的非接触标测导管，网篮状的 6 支导管上分布有 48 个超声换能器和 48 个电极。超声换能器能以 115 000 点/min 的速度对心腔进行采样，快速创建解剖重建；电极每秒采集有 150 000个样本，以生成实时三维电激动图，并将二者相整合。Liebregts 等[27] 首次将 AcQMap 导管应用于 24 例持续性房颤和 7 例不典型房扑的消融过程，该系统操作方便且安全，能准确地描绘折返环路和心房的激动模式，不典型房扑消融即刻成功率为 86%，随访 1 年后 57% 的不典型房扑患者未复发房性心律失常。

高精密度标测与低精密度标测相比，能缩短手术时间和透视时间，有效降低术后短期和长期的房性心律失常复发率[28-29]。但在峡部上可能存在肌肉组织过厚、心外膜连接、损伤周围血管和神经等实际困难，还需针对患者制定合适的消融策略，才能事半功倍。

5 左心房房扑的消融术式

由于发生机制不同，左心房房扑常有多种多样的折返环路，需要通过详细的电生理检查找到解剖峡部或者功能峡部，以实现峡部线双向阻滞或反复心房刺激不能诱发房性心律失常为消融终点。以最为常见的左心房房扑即二尖瓣峡部依赖型房扑为例，通常以线性连接左下肺静脉与二尖瓣环作为二尖瓣峡部依赖型房扑的消融靶点。Wittkampf 等[30] 解剖了 16 例正常的左心房后发现二尖瓣环附近的心肌相对较薄，理论上低功率的射频能量足以造成透壁消融。但由于二尖瓣峡部临近解剖结构复杂、心房动静脉血流带走消融热量、组织贴靠不良等原因造成实现透壁、双向阻滞有较大困难[31]。由此，前间隔线消融（连接右上肺静脉至二尖瓣环前间隔部）、改良前壁线消融（连接左心耳前至二尖瓣环前侧部）、心房基质改良、左心耳峡部消融等虽逐渐被提出用于治疗二尖瓣峡部依赖型房扑[32-35]，但仍面临着心肌更厚、峡部更长和导致心脏压塞风险增加等挑战[36-37]。多篇文献[38-42] 报道，冠状静脉窦、Marshall 静脉、Bachmann 束等左心房心外膜结构也可加入折返环路中，常需联合 Marshall 静脉酒精消融和心外膜消融等方式才能终止房扑。

多年来，应用于不典型房扑的消融导管也在不断发展。由 4 mm 和 8 mm 温控消融导管发展至开放式冷盐水灌注消融导管，并逐渐广泛应用，成为房扑消融的首选。在使用开放式冷盐水灌注消融导管时，通常将温度预设置为 43 ℃，维持功率输出在 30 ~ 50 W，最长持续时间 60 s。心内膜消融下对于不同的消融功率还需要不同的灌注速度，以确保手术安全[43]。最近的研究发现使用压力感知导管可提高手术成功率[19]，更推荐使用带有压力感知功能的消融导管用于房扑消融。

对于左心房房扑的消融术式，是应用“one-for-all”的通用术式，还是应用个体化的消融策略尚有争议。Pott 等[44] 在治疗 47 例首次消融的左心房房扑过程中，首次通过随机对比基于 EAM 系统得到的个体化的心房基质消融策略与基于解剖的标准消融策略，两组手术即刻成功率无显著差异，但随访 2.5 年后，基于心房基质消融策略组无不典型房扑发生率明显较高（48.8% vs 21.5%，$P = 0.047$），提示个体化的消融策略能提高左心房房扑的远期无房性心律失常患者的生存率。Cherian 等[14] 基于 EAM 系统使用肺静脉隔离 + 线性消融术治疗了 20 例特发性左心房房扑，随访期间有 7 例患者再次行射频消融术，1 例患者又经过了 2 次射频消融术，平均随访 21 个月后，16 例患者未复发，13 例患者不需服用抗心律失常药，因此认为肺静脉隔离 + 线性消融术治疗左心房房扑是有效的。由于左心房房扑在人群中的发病率较低，缺乏对于左

心房房扑术中同时行肺静脉隔离是否有助于改善预后的大规模、前瞻性随机对照研究。

6　房室结消融与希氏束起搏

尽管随着标测和消融技术的发展,左心房房扑的消融取得了进展,但由于各种原因根治性消融无法终止房扑,许多患者可能仍需要控制心律。房室结消融作为控制心律的一种治疗选择,其主要的限制是需植入永久起搏器。右心室起搏会导致心室不同步甚至心功能不全,而永久性希氏束起搏可诱导生理性心室收缩,从而防止长期的心室功能障碍。Moriña-Vázquez 等[45]发现对于难以控制的持续性房颤和不典型房扑患者经房室结消融术 + 永久性希氏束起搏后,可有效改善症状和心功能分级,还可明显改善射血分数降低性心力衰竭患者的左室射血分数。

7　总结和展望

随着 EAM 系统和脉冲电场消融等消融手段的快速发展并被应用于临床实践,电生理医生对于心律失常发生机制的认识不断增强,能够为患者选择更佳的个性化消融策略,顺利终止心律失常和减少并发症,实现更快、更安全、更成功的介入治疗,使包括左心房房扑在内的各种复杂疑难心律失常的治疗成功率不断提高,最终改善患者的健康和生活质量。

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