DOI:10.16781/j.CN31-2187/R.20211160

·综 述·

# 导管消融联合左心耳封堵在心房颤动患者中的应用进展

赵 耀，赵 腾，赵海娟，李 珂，黄松群，白 元，曹 江，郭志福，黄新苗*
海军军医大学（第二军医大学）第一附属医院心血管内科，上海 200433

［摘要］ 心房颤动是临床上最常见的心律失常，其症状可导致患者生活质量下降，并增加患者缺血性脑卒中和心力衰竭的发生风险。导管消融术能有效缓解心房颤动患者的症状，但目前还没有足够的证据表明其可降低脑卒中的发生率。左心耳封堵术是心房颤动卒中预防的有效手段，导管消融联合左心耳封堵的一站式手术适用于高脑卒中、高脑出血风险的非瓣膜性心房颤动患者。本文综述了心房颤动导管消融联合左心耳封堵一站式手术的安全性、有效性及其疗效的影响因素，以供临床参考借鉴。

［关键词］ 心房颤动；导管消融术；左心耳封堵；一站式
［中图分类号］ R 541.75 ［文献标志码］ A ［文章编号］ 2097-1338(2022)08-0936-07

**Application of catheter ablation combined with left atrial appendage closure in patients with atrial fibrillation: recent progress**

ZHAO Yao, ZHAO Teng, ZHAO Hai-juan, LI Ke, HUANG Song-qun, BAI Yuan, CAO Jiang, GUO Zhi-fu, HUANG Xin-miao*
Department of Cardiovasology, The First Affiliated Hospital of Naval Medical University (Second Military Medical University), Shanghai 200433, China

［**Abstract**］ Atrial fibrillation (AF) is one of the most common arrhythmias in clinical scenario and its symptoms can lead to a decline in the quality of life and increase the risk of ischemic stroke and heart failure in patients. Catheter ablation can effectively relieve the symptoms of AF patients, but there is no enough evidence that it reduces the incidence of stroke. Left atrial appendage closure is an effective method for the prevention of stroke caused by AF. The one-stop operation of catheter ablation combined with left atrial appendage closure is suitable for nonvalvular AF patients with high risk of stroke and bleeding. This article reviews the safety, effectiveness and influencing factors of the efficacy of catheter ablation combined with left atrial appendage closure for clinical reference.

［**Key words**］ atrial fibrillation; catheter ablation; left atrial appendage closure; one-stop
［Acad J Naval Med Univ, 2022, 43(8): 936-942］

心房颤动（atrial fibrillation，AF）是临床上最常见的心律失常，其心悸等症状严重影响着患者的生活质量，并且会增加患者缺血性脑卒中和心力衰竭的发生风险。导管消融术在心律控制方面比抗心律失常药物更有优势，是缓解症状的有效方法，因此导管消融成为药物难治性AF的一线治疗手段[1-3]。但导管消融治疗AF的远期预后仍不令人满意[4-5]，并且目前还没有前瞻性随机对照试验表明导管消融术可以显著降低血栓栓塞事件的发生风险[6]。

AF患者的脑卒中风险是正常人的5倍[7]。最新的AF诊断与管理指南建议，对于有高脑卒中风险的AF患者，导管消融术后无论是否维持窦性心律，都应长期使用口服抗凝药（oral anticoagulant，OAC）[4]。目前的OAC主要分为2类：一类是维生素K拮抗剂，如华法林。研究表明，华法林可以显著降低AF患者脑卒中风险[8]。但华法林也有一些无法回避的缺点，如出血、易与食物和药物发生相互作用、需定时监测国际标准化比值（international normalized ratio，INR）、治疗窗窄、起效慢等[9]。另一类是直接OAC，如达

［收稿日期］ 2021-11-16 ［接受日期］ 2022-04-29
［基金项目］ 国家自然科学基金（81770506），海军军医大学（第二军医大学）第一附属医院“234学科攀峰计划”（2020YXK010）. Supported by National Natural Science Foundation of China (81770506) and “234 Discipline Climbing Plan” of The First Affiliated Hospital of Naval Medical University (Second Military Medical University) (2020YXK010).
［作者简介］ 赵 耀，硕士生. E-mail: 1120629607@qq.com
*通信作者（Corresponding author）. Tel: 021-31161262, E-mail: huangxinmiao@hotmail.com

比加群、利伐沙班等，它们相较于华法林服药方便且起效快，但仍存在脑出血风险高的问题[9]。非瓣膜性 AF 患者中，90% 甚至更高比例的血栓来源于左心耳[10-14]，因此可以用左心耳封堵来替代 OAC 预防 AF 患者脑卒中的发生。在有高脑出血风险的 AF 患者中，左心耳封堵术成为了一种可以替代终身抗凝治疗的有效办法[15-16]。本文综述了 AF 导管消融联合左心耳封堵一站式手术的安全性、有效性及其疗效的影响因素，以供临床参考借鉴。

## 1　AF 一站式手术治疗的理论基础

心源性血栓形成的部位大多位于左心耳，AF 是左心耳血栓形成的首要原因，可以认为左心耳排空功能正常的患者没有 AF 即不会发生左心耳相关血栓，因此评估 AF 的消融成功率非常重要。不发作 AF 的患者发生左心耳血栓的概率很低，左心耳封堵可以认为是消融不成功或已丧失消融时机患者的无奈选择，左心耳封堵仅能预防心源性血栓栓塞的发生，并不能解决 AF 相关症状。如果评估 AF 患者持续时间偏短，AF 波偏大，术前肺静脉－左心房 CT 形态显示左心房体积增加不明显、肺静脉宽度尚可，AF 的消融成功率可能会高一些[4,17-19]。此外，可以术中观察放置冠状窦电极，评估冠状窦电位大小。冠状窦电位偏大者提示左心房纤维化程度低，预测消融成功率将会较高[20-21]。术中评估冠状窦电位后可以给予尼非卡兰或伊布利特，如果药物可以成功转复 AF，提示心房纤维化程度低，推测消融成功率将会较高[22-23]；反之，消融成功率可能较低。对于评估 AF 消融成功率高者可以行 AF 消融。术中根据左心房－左心耳造影结果评估左心耳排空功能和左心耳梳状肌的多少与发达程度，也可预测是否会发生左心耳相关血栓[24]。如果评估 AF 消融成功率偏低，而且有左心耳封堵适应证者，可以行左心耳封堵；对于既不行 AF 消融，又不行左心耳冷冻者，药物治疗也是一种选择。

2012 年，荷兰医师 Swaans 等[25]首次报道了射频消融合并左心耳封堵的联合术式，30 例 AF 患者全部成功行射频消融联合左心耳封堵，初步证实一站式手术的可行性。同年，澳大利亚医师 Walker 等[26]也报道了 26 例 AF 患者同时成功接受射频消融联合左心耳封堵术。该研究首次提到消融术中冷盐水灌注对左心房压力的影响及消融术后肺静脉嵴的水肿问题，但认为不影响封堵器尺寸的选择。

导管消融术与左心耳封堵术均需穿刺股静脉、房间隔，均需在左心房操作，因此 2 种手术的联合可以减少一次额外的手术风险，节约一部分手术器材费用和住院费用[27]，最重要的是可以达到恢复窦性心律、缓解症状及预防脑卒中、降低出血风险等多重目的[28]。因此，对于消融不能长期维持窦性心律的患者，可行导管消融联合左心耳封堵一站式手术。

## 2　AF 一站式手术的适应证选择

相较于单纯的导管消融或左心耳封堵治疗，一站式手术的适应证更加严格，它实际上是导管消融和左心耳封堵适应证的交集。总体来说，一站式手术的适应证包括以下几点：（1）高脑卒中风险，$CHA_2DS_2$-VASc（congestive heart failure, hypertension, age≥75 years, diabetes mellitus, previous stroke/transient ischemic attack, vascular disease, age 65-74, and sex category）评分≥2 的非瓣膜性 AF 患者，或已接受左心耳电隔离的患者；（2）高脑出血风险，HAS-BLED（hypertension, abnormal renal/liver function, stroke, bleeding history or predisposition, labile INR, elderly, drugs/alcohol concomitantly）评分≥3 的非瓣膜性 AF 患者；（3）药物治疗无效的症状性非瓣膜性 AF，症状影响患者生活质量，需要行导管消融来恢复和维持窦性心律；（4）依从性差，如认知功能较差，不能按时服药的老年患者[4]。

## 3　AF 一站式手术的有效性

AF 消融联合左心耳封堵是最常见的联合术式，从单中心经验[25-26]到多中心研究[29-30]，理论和技术日趋成熟。meta 分析显示，非瓣膜性 AF 患者导管消融联合左心耳封堵的手术成功率为 98%，心包并发症发生率为 1%，证明导管消融联合左心耳封堵一站式手术安全、有效[31]。

导管消融可以减少房性心律失常发作，并提高患者生活质量。2019 年的一项随机对照试验 CIRCA-DOSE[32]采用有创的植入式循环记录仪监测 AF 负荷，结果表明无论射频还是冷冻球囊消融，均使 AF 负荷下降超过 98%。多项研究显示，在有症状的 AF 患者中，与药物治疗相比，导管消

融在术后 12 个月时可显著改善患者的生活质量[33-34]。

左心耳封堵术对于 AF 患者的脑卒中预防安全且有效。PROTECT-AF 研究[35-38]、补充研究（ASAP 研究）[39]及更新研究（PREVAIL 研究）[40]都是关于 Watchman 封堵器对 AF 患者脑卒中预防的临床试验。PROTECT-AF 研究的早期、中期随访结果均显示，左心耳封堵组的有效性不劣于华法林组，然而不良安全性事件发生率较高[35-36]。但是，PROTECT-AF 研究的晚期随访结果证明在安全性上不劣于华法林组[37]。CAP 研究报道，随着术者经验的增加，左心耳封堵术围手术期的安全事件发生率越低[38]。ASAP 研究结果显示，左心耳封堵术能在没有华法林过渡的情况下安全进行，是有 OAC 禁忌的高脑卒中风险的非瓣膜性 AF 患者的合理选择[39]。与 PROTECT-AF 研究相比，PREVAIL 研究入选的 AF 患者 $CHADS_2$（congestive heart failure, hypertension, age≥75 years, diabetes mellitus, and previous stroke/transient ischemic attack）评分相对较高，因此更接近真实世界的情况[40]。

一站式手术可以显著降低预期的脑卒中事件与出血事件的发生率。2020 年，Phillips 等[29]发表了一项为期 2 年的国际间多中心注册研究。随访结果显示，一站式术后脑卒中的风险降低了 93%，同时非手术相关的脑出血风险降低 70%。这一结果与另外 2 项多中心注册研究中长期随访的导管消融联合左心耳封堵术研究[30,41]结果一致。一站式手术的中长期疗效尚需要前瞻性、随机对照研究进一步证实。

一站式手术可以改善左心房心肌重构。与国外相比，我国一站式手术的病例数更多，细节分析更加深入。Li 等[42]研究发现，一站式手术后维持窦性心律的患者左心房容积明显减小。同时该研究提示，左心耳容积 / 左心房容积比值越小、氨基末端脑钠肽前体（N-terminal pro-brain natriuretic peptide，NT-proBNP）水平越高或基线时左心室射血分数越低，左心房结构逆向重构越显著。

先前有文献报道了 AF 消融和左心耳封堵对左心房容积变化的相反作用[43-44]，AF 消融导致左心房容积减少（逆向重构）[43]，而左心耳封堵引起左心房扩大（重构）[44]。因此，伴随消融的左心耳封堵可能通过逆转封堵引起的左心房重构而使患者受益，这一点得到 Li 等[42]先前基于心脏 CT 评估研究的证实。同时，手术后 NT-proBNP 水平明显降低，提示心力衰竭缓解。

在 Chen 等[45]的研究中，在随访 3 个月和 1 年时 NT-proBNP 的水平与基线相比显着降低。然而，超声心动图参数，包括左心室射血分数、左心房直径、左心室舒张末期和收缩末期直径没有明显差异。这可能是由于超声心动图测试之间的可重复性有限及操作者内部和操作者之间的差异所致。此外，逆向重构可能是长期过程，需要进一步随访。

虽然左心耳作为左心房的一部分，可以作为容量缓冲器官缓解左心房压力，具有生理功能，左心耳封堵后，左心耳作为容量缓冲器官的功能丧失，但 meta 分析显示，左心耳封堵在预防死亡、脑卒中或系统性血栓事件上与新型 OAC 相当甚至更优[46-47]。左心耳封堵使左心耳机械功能丧失，但多项研究表明，左心耳封堵对左心房的结构或功能没有显著影响[48-50]，甚至有研究显示，左心耳封堵术后左心房储备功能及收缩功能显著改善，其改善继发于 Frank-Starling 效应而不是其内在收缩性的改变[51]。

## 4　AF 一站式手术的安全性

与 AF 单独消融或单纯封堵相比，导管消融联合左心耳封堵并不会更安全，其手术安全性仍不容忽视。就房间隔穿刺而言，消融患者穿间隔位置建议偏后，而左心耳封堵患者穿间隔位置建议偏前，2 个手术所需的房间隔穿刺位置并不一定相同，两者有时不能兼顾，甚至有时需要分别行房间隔穿刺。多项研究显示，左心耳封堵术后 45 d、6 个月、12 个月器械相关房间隔缺损的发生率分别为 34%～37%、11%、7%，但对死亡、心力衰竭再入院等临床结局的发生无显著影响[52-53]。一站式手术也存在封堵器脱落、封堵器周围残余分流、心包填塞、左心房食管瘘等风险。2019 年，Liu 等[41]研究了一站式手术的安全性和中期结果。该研究纳入了 50 例非瓣膜性 AF 患者，围手术期观察到心包填塞 2 例、周围血管并发症 1 例和轻度空气栓塞 1 例。术后 6 周经食管心脏超声检查显示，43 例患者的左心耳封堵完全。虽然 6 例有少量的封堵器周围渗漏（＜5 mm），但其中有 2 例在术后 6 个月随访时左心耳封堵完全。平均随访（20.2±11.5）个月后，18 例出现房性心律失常复发，

45 例表现为左心耳完全封堵。该研究表明导管消融联合左心耳封堵的一站式手术是安全可行的，但其中期安全性有必要进一步验证。

2018 年，Wintgens 等[30]开展了 5 个注册中心的前瞻性研究。导管消融联合左心耳封堵一站式术后数小时内，1 例患者发生轻度脑卒中，随访的 30 d 内未发生死亡。30 d 的围手术期并发症包括轻微的腹股沟血肿（4.4%）、心包积液（1.5%）。77.9% 的患者 3 个月随访时经食管心脏超声检查显示 98.9% 的左心耳封堵器成功植入，70.2% 的左心耳封堵器封堵完全，28.6% 的封堵器有少量残余分流，仅 0.7% 的患者存在残余分流＞5 mm。1 例患者在术后第 6 周常规随访时发现封堵器脱落并成功取出，3 例患者观察到封堵器相关血栓，并继续抗凝后血栓溶解。该研究的总体无并发症率为 92.8%。以上研究表明，虽然 AF 一站式手术有一些已知或未知的风险，但总体并发症发生率较低，手术安全性较好。

与射频消融相比，冷冻消融更有可能改变左心耳口形状，造成肺静脉嵴水肿，因此理论上对左心耳的干扰更大。然而，Ren 等[54]研究发现，冷冻消融联合左心耳封堵的短期安全性和有效性与单独冷冻消融相当，鉴于冷冻消融后出现的肺静脉嵴水肿，该研究认为 Watchman 封堵器更适合一站式治疗。

## 5　AF 一站式手术的组合策略

AF 一站式手术的疗效与手术组合策略有关。一站式手术的安全性与有效性已被证明，但是它们的最佳组合策略有待进一步研究。

目前主流的一站式手术方式是先消融后封堵。Phillips 等[29]、Fassini 等[55]与 Wintgens 等[30]的一站式研究在长期随访中均证实了先消融后封堵策略的有效性和安全性。

中国储慧民团队研究发现，盘式封堵器和塞式封堵器均可用于一站式手术[56]，并于 2018 年发表了一项探究不同组合策略对临床结局影响的研究[57]。该研究入选了 82 例有症状的 AF 患者，其中先封堵组 52 例、先消融组 30 例，并进行了回顾性分析以评估每种手术策略的优势。结果显示，不论是先封堵还是先消融策略，在非瓣膜性 AF 的联合治疗中都是安全、有效的。然而，在随访过程中，先封堵后消融策略发生残余漏的概率更低，这可能与导管消融肺静脉会导致左心耳局部水肿，进而影响封堵效果有关。

## 6　结　语

对于具有高脑卒中风险和高脑出血风险的非瓣膜性 AF 患者来说，导管消融联合左心耳封堵的一站式手术可同时实现 AF 的节律控制和血栓栓塞预防，并能够减少长期使用抗凝药物引起的出血并发症，具有较高的有效性和安全性。

## ［参 考 文 献］


［1］ ORAL H, PAPPONE C, CHUGH A, GOOD E, BOGUN F, PELOSI F Jr, et al. Circumferential pulmonary-vein ablation for chronic atrial fibrillation[J]. N Engl J Med, 2006, 354: 934-941.

［2］ PAPPONE C, AUGELLO G, SALA S, GUGLIOTTA F, VICEDOMINI G, GULLETTA S, et al. A randomized trial of circumferential pulmonary vein ablation versus antiarrhythmic drug therapy in paroxysmal atrial fibrillation: the APAF Study[J]. J Am Coll Cardiol, 2006, 48: 2340-2347.

［3］ STABILE G, BERTAGLIA E, SENATORE G, DE SIMONE A, ZOPPO F, DONNICI G, et al. Catheter ablation treatment in patients with drug-refractory atrial fibrillation: a prospective, multi-centre, randomized, controlled study (Catheter Ablation For The Cure Of Atrial Fibrillation Study)[J]. Eur Heart J, 2006, 27: 216-221.

［4］ HINDRICKS G, POTPARA T, DAGRES N, ARBELO E, BAX J J, BLOMSTRÖM-LUNDQVIST C, et al. 2020 ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): the task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC[J]. Eur Heart J, 2021, 42: 373-498.

［5］ WEERASOORIYA R, KHAIRY P, LITALIEN J, MACLE L, HOCINI M, SACHER F, et al. Catheter ablation for atrial fibrillation: are results maintained at 5 years of follow-up?[J]. J Am Coll Cardiol, 2011, 57: 160-166.

［6］ PACKER D L, MARK D B, ROBB R A, MONAHAN K H, BAHNSON T D, POOLE J E, et al. Effect of catheter ablation vs antiarrhythmic drug therapy on mortality, stroke, bleeding, and cardiac arrest among patients with atrial fibrillation: the CABANA randomized clinical trial[J]. JAMA, 2019, 321: 1261-1274.

[7] LLOYD-JONES D M, WANG T J, LEIP E P, LARSON M G, LEVY D, VASAN R S, et al. Lifetime risk for development of atrial fibrillation: the Framingham Heart Study[J]. Circulation, 2004, 110: 1042-1046.

[8] HART R G, PEARCE L A, AGUILAR M I. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation[J]. Ann Intern Med, 2007, 146: 857-867.

[9] RUFF C T, GIUGLIANO R P, BRAUNWALD E, HOFFMAN E B, DEENADAYALU N, EZEKOWITZ M D, et al. Comparison of the efficacy and safety of new oral anticoagulants with warfarin in patients with atrial fibrillation: a meta-analysis of randomised trials[J]. Lancet, 2014, 383: 955-962.

[10] STODDARD M F, DAWKINS P R, PRINCE C R, AMMASH N M. Left atrial appendage thrombus is not uncommon in patients with acute atrial fibrillation and a recent embolic event: a transesophageal echocardiographic study[J]. J Am Coll Cardiol, 1995, 25: 452-459.

[11] BLACKSHEAR J L, ODELL J A. Appendage obliteration to reduce stroke in cardiac surgical patients with atrial fibrillation[J]. Ann Thorac Surg, 1996, 61: 755-759.

[12] LIP G Y H, HAMMERSTINGL C, MARIN F, CAPPATO R, MENG I L, KIRSCH B, et al. Left atrial thrombus resolution in atrial fibrillation or flutter: results of a prospective study with rivaroxaban (X-TRA) and a retrospective observational registry providing baseline data (CLOT-AF)[J]. Am Heart J, 2016, 178: 126-134.

[13] CRESTI A, GARCÍA-FERNÁNDEZ M A, SIEVERT H, MAZZONE P, BARATTA P, SOLARI M, et al. Prevalence of extra-appendage thrombosis in non-valvular atrial fibrillation and atrial flutter in patients undergoing cardioversion: a large transoesophageal echo study[J/OL]. EuroIntervention, 2019, 15: e225-e230. DOI: 10.4244/EIJ-D-19-00128.

[14] PARASHAR A, SUD K, DEVGUN J, AGARWAL S, BASSI M, TUZCU E M, et al. Feasibility of LAA closure for left atrial thrombus in patients with aortic stenosis and AF[J]. J Am Coll Cardiol, 2016, 68: 770-771.

[15] HOLMES D R Jr, DOSHI S K, KAR S, PRICE M J, SANCHEZ J M, SIEVERT H, et al. Left atrial appendage closure as an alternative to warfarin for stroke prevention in atrial fibrillation: a patient-level meta-analysis[J]. J Am Coll Cardiol, 2015, 65: 2614-2623.

[16] KOTALCZYK A, MAZUREK M, KALARUS Z, POTPARA T S, LIP G Y H. Stroke prevention strategies in high-risk patients with atrial fibrillation[J]. Nat Rev Cardiol, 2021, 18: 276-290.

[17] ZARZOSO V, LATCU D G, HIDALGO-MUÑOZ A R, MEO M, MESTE O, POPESCU I, et al. Non-invasive prediction of catheter ablation outcome in persistent atrial fibrillation by fibrillatory wave amplitude computation in multiple electrocardiogram leads[J]. Arch Cardiovasc Dis, 2016, 109: 679-688.

[18] KAUFMANN R, REZAR R, STROHMER B, WERNLY B, LICHTENAUER M, HITZL W, et al. Left atrial ejection fraction assessed by prior cardiac CT predicts recurrence of atrial fibrillation after pulmonary vein isolation[J/OL]. J Clin Med, 2021, 10: 752. DOI: 10.3390/jcm10040752.

[19] KIUCHI K, YOSHIDA A, TAKEI A, FUKUZAWA K, ITOH M, IMAMURA K, et al. Topographic variability of the left atrium and pulmonary veins assessed by 3D-CT predicts the recurrence of atrial fibrillation after catheter ablation[J]. J Arrhythm, 2015, 31: 286-292.

[20] ATTANASIO P, QAIYUMI D, RÖHLE R, WUTZLER A, SAFAK E, MUNTEAN B, et al. Coronary sinus signal amplitude predicts left atrial scarring[J]. Acta Cardiol, 2017: 1-6.

[21] TEH A W, KALMAN J M, KISTLER P M, LEE G, SUTHERLAND F, MORTON J B, et al. Prevalence of fractionated electrograms in the coronary sinus: comparison between patients with persistent or paroxysmal atrial fibrillation and a control population[J]. Heart Rhythm, 2010, 7: 1200-1204.

[22] DI C Y, GAO P, WANG Q, WU Y X, LIN W H. Intraprocedural conversion efficacy of intravenous nifekalant administration for persistent atrial fibrillation after pulmonary vein isolation[J]. Int Heart J, 2020, 61: 1157-1164.

[23] HE S N, TIAN Y, SHI L, WANG Y J, XIE B Q, LI X X, et al. Identification of circumferential pulmonary vein isolation responders among patients with persistent atrial fibrillation: clinical value of the sequential low-dose ibutilide test[J]. Europace, 2020, 22: 1197-1205.

[24] SPAGNOLO P, GIGLIO M, DI MARCO D, CANNAÒ P M, AGRICOLA E, DELLA BELLA P E, et al. Diagnosis of left atrial appendage thrombus in patients with atrial fibrillation: delayed contrast-enhanced cardiac CT[J]. Eur Radiol, 2021, 31: 1236-1244.

[25] SWAANS M J, POST M C, RENSING B J W M, BOERSMA L V A. Ablation for atrial fibrillation in combination with left atrial appendage closure: first results of a feasibility study[J/OL]. J Am Heart Assoc, 2012, 1: e002212. DOI: 10.1161/JAHA.112.002212.

[26] WALKER D T, HUMPHRIES J A, PHILLIPS K P. Combined catheter ablation for atrial fibrillation and Watchman® left atrial appendage occlusion procedures: a single centre experience[J/OL]. J Atr Fibrillation,

2012, 5: 687. DOI: 10.4022/jafib.687.

[27] KAWAKAMI H, NOLAN M T, PHILLIPS K, SCUFFHAM P A, MARWICK T H. Cost-effectiveness of combined catheter ablation and left atrial appendage closure for symptomatic atrial fibrillation in patients with high stroke and bleeding risk[J]. Am Heart J, 2021, 231: 110-120.

[28] GLIKSON M, WOLFF R, HINDRICKS G, MANDROLA J, CAMM A J, LIP G Y H, et al. EHRA/EAPCI expert consensus statement on catheter-based left atrial appendage occlusion—an update[J]. EuroIntervention, 2020,15: 1133-1180.

[29] PHILLIPS K P, ROMANOV A, ARTEMENKO S, FOLKERINGA R J, SZILI-TOROK T, SENATORE G, et al. Combining left atrial appendage closure and catheter ablation for atrial fibrillation: 2-year outcomes from a multinational registry[J]. Europace, 2020, 22: 225-231.

[30] WINTGENS L, ROMANOV A, PHILLIPS K, BALLESTEROS G, SWAANS M, FOLKERINGA R, et al. Combined atrial fibrillation ablation and left atrial appendage closure: long-term follow-up from a large multicentre registry[J]. Europace, 2018, 20: 1783-1789.

[31] JIANG Y, LI F H, LI D Z, CHENG Y S, JIA Y, FU H, et al. Efficacy and safety of catheter ablation combined with left atrial appendage occlusion for nonvalvular atrial fibrillation: a systematic review and meta-analysis[J]. Pacing Clin Electrophysiol, 2020, 43: 123-132.

[32] ANDRADE J G, CHAMPAGNE J, DUBUC M, DEYELL M W, VERMA A, MACLE L, et al. Cryoballoon or radiofrequency ablation for atrial fibrillation assessed by continuous monitoring: a randomized clinical trial[J]. Circulation, 2019, 140: 1779-1788.

[33] BLOMSTRÖM-LUNDQVIST C, GIZURARSON S, SCHWIELER J, JENSEN S M, BERGFELDT L, KENNEBÄCK G, et al. Effect of catheter ablation vs antiarrhythmic medication on quality of life in patients with atrial fibrillation: the CAPTAF randomized clinical trial[J]. JAMA, 2019, 321: 1059-1068.

[34] MARK D B, ANSTROM K J, SHENG S B, PICCINI J P, BALOCH K N, MONAHAN K H, et al. Effect of catheter ablation vs medical therapy on quality of life among patients with atrial fibrillation: the CABANA randomized clinical trial[J]. JAMA, 2019, 321: 1275-1285.

[35] HOLMES D R, REDDY V Y, TURI Z G, DOSHI S K, SIEVERT H, BUCHBINDER M, et al. Percutaneous closure of the left atrial appendage versus warfarin therapy for prevention of stroke in patients with atrial fibrillation: a randomised non-inferiority trial[J]. Lancet, 2009, 374: 534-542.

[36] REDDY V Y, DOSHI S K, SIEVERT H, BUCHBINDER M, NEUZIL P, HUBER K, et al. Percutaneous left atrial appendage closure for stroke prophylaxis in patients with atrial fibrillation: 2.3-year follow-up of the PROTECT AF (Watchman Left Atrial Appendage System for Embolic Protection in Patients with Atrial Fibrillation) Trial[J]. Circulation, 2013, 127: 720-729.

[37] REDDY V Y, SIEVERT H, HALPERIN J, DOSHI S K, BUCHBINDER M, NEUZIL P, et al. Percutaneous left atrial appendage closure vs warfarin for atrial fibrillation: a randomized clinical trial[J]. JAMA, 2014, 312: 1988-1998.

[38] REDDY V Y, HOLMES D, DOSHI S K, NEUZIL P, KAR S. Safety of percutaneous left atrial appendage closure: results from the Watchman Left Atrial Appendage System for Embolic Protection in Patients with AF (PROTECT AF) clinical trial and the Continued Access Registry[J]. Circulation, 2011, 123: 417-424.

[39] REDDY V Y, MÖBIUS-WINKLER S, MILLER M A, NEUZIL P, SCHULER G, WIEBE J, et al. Left atrial appendage closure with the Watchman device in patients with a contraindication for oral anticoagulation: the ASAP study (ASA Plavix Feasibility Study With Watchman Left Atrial Appendage Closure Technology)[J]. J Am Coll Cardiol, 2013, 61: 2551-2556.

[40] HOLMES D R Jr, KAR S, PRICE M J, WHISENANT B, SIEVERT H, DOSHI S K, et al. Prospective randomized evaluation of the Watchman Left Atrial Appendage Closure device in patients with atrial fibrillation versus long-term warfarin therapy: the PREVAIL trial[J]. J Am Coll Cardiol, 2014, 64: 1-12.

[41] LIU F Z, LIN W D, LIAO H T, PENG J, XUE Y M, ZHAN X Z, et al. Mid-term outcomes of concomitant left atrial appendage closure and catheter ablation for non-valvular atrial fibrillation: a multicenter registry[J]. Heart Vessels, 2019, 34: 860-867.

[42] LI Y G, GONG C Q, ZHAO M Z, SUN J, WANG Q S, ZHANG P P, et al. Determinants of postoperative left atrial structural reverse remodeling in patients undergoing combined catheter ablation of atrial fibrillation and left atrial appendage closure procedure[J]. J Cardiovasc Electrophysiol, 2019, 30: 1868-1876.

[43] JEEVANANTHAM V, NTIM W, NAVANEETHAN S D, SHAH S, JOHNSON A C, HALL B, et al. Meta-analysis of the effect of radiofrequency catheter ablation on left atrial size, volumes and function in patients with atrial fibrillation[J]. Am J Cardiol, 2010, 105: 1317-1326.

[44] PHAN Q T, SHIN S Y, CHO I S, LEE W S, WON H, SHARMIN S, et al. Impact of left atrial appendage closure on cardiac functional and structural remodeling: a difference-in-difference analysis of propensity score matched samples[J]. Cardiol J, 2019, 26: 519-528.

［45］ CHEN M, WANG Z Q, WANG Q S, SUN J, ZHANG P P, FENG X F, et al. One-stop strategy for treatment of atrial fibrillation: feasibility and safety of combining catheter ablation and left atrial appendage closure in a single procedure[J]. Chin Med J (Engl), 2020, 133: 1422-1428.

［46］ SAHAY S, NOMBELA-FRANCO L, RODES-CABAU J, JIMENEZ-QUEVEDO P, SALINAS P, BIAGIONI C, et al. Efficacy and safety of left atrial appendage closure versus medical treatment in atrial fibrillation: a network meta-analysis from randomised trials[J]. Heart, 2017, 103: 139-147.

［47］ LI X, WEN S N, LI S N, BAI R, LIU N, FENG L, et al. Over 1-year efficacy and safety of left atrial appendage occlusion versus novel oral anticoagulants for stroke prevention in atrial fibrillation: a systematic review and meta-analysis of randomized controlled trials and observational studies[J]. Heart Rhythm, 2016, 13: 1203-1214.

［48］ AZIZY O, LIND A, JANOSI R A, RASSAF T, RAMMOS C. Preserved left atrial function following left atrial appendage closure for stroke prevention[J]. J Invasive Cardiol, 2021, 33: E40-E44.

［49］ YANG J, LIU Y, FENG L, LIU M Q, YOU L, LIU Y, et al. Effect of left atrial appendage closure in combination with catheter ablation on left atrial function for persistent atrial fibrillation[J/OL]. Front Cardiovasc Med, 2021, 8: 666465. DOI: 10.3389/fcvm.2021.666465.

［50］ HANNA I R, KOLM P, MARTIN R, REISMAN M, GRAY W, BLOCK P C. Left atrial structure and function after percutaneous left atrial appendage transcatheter occlusion (PLAATO): six-month echocardiographic follow-up[J]. J Am Coll Cardiol, 2004, 43: 1868-1872.

［51］ COISNE A, PILATO R, BRIGADEAU F, KLUG D, MARQUIE C, SOUISSI Z, et al. Percutaneous left atrial appendage closure improves left atrial mechanical function through Frank-Starling mechanism[J]. Heart Rhythm, 2017, 14: 710-716.

［52］ SINGH S M, DOUGLAS P S, REDDY V Y. The incidence and long-term clinical outcome of iatrogenic atrial septal defects secondary to transseptal catheterization with a 12F transseptal sheath[J]. Circ Arrhythm Electrophysiol, 2011, 4: 166-171.

［53］ PUGA L, TEIXEIRA R, PAIVA L, RIBEIRO J M, GAMEIRO J, SOUSA J P, et al. Iatrogenic atrial septal defect after percutaneous left atrial appendage closure: a single-center study[J]. Int J Cardiovasc Imaging, 2021, 37: 2359-2368.

［54］ REN Z Y, ZHANG J, ZHU M Y, ZHAO D D, LI S, YANG H T, et al. Cryoablation combined with left atrial appendage closure: a safe and effective procedure for paroxysmal atrial fibrillation patients[J/OL]. Cardiol Res Pract, 2020, 2020: 6573296. DOI: 10.1155/2020/6573296.

［55］ FASSINI G, CONTI S, MOLTRASIO M, MALTAGLIATI A, TUNDO F, RIVA S, et al. Concomitant cryoballoon ablation and percutaneous closure of left atrial appendage in patients with atrial fibrillation[J]. Europace, 2016, 18: 1705-1710.

［56］ DU X F, CHU H M, YE P, HE B, XU H Q, JIANG S B, et al. Combination of left atrial appendage closure and catheter ablation in a single procedure for patients with atrial fibrillation: multicenter experience[J]. J Formos Med Assoc, 2019, 118: 891-897.

［57］ DU X F, CHU H M, HE B, WANG B H, LIU J, FENG M J, et al. Optimal combination strategy of left atrial appendage closure plus catheter ablation in a single procedure in patients with nonvalvular atrial fibrillation[J]. J Cardiovasc Electrophysiol, 2018, 29: 1089-1095.

［本文编辑］　商素芳