Année 2022/2023 N°

Thèse

Pour le

DOCTORAT EN MEDECINE

Diplôme d'État

par

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Né le 25/05/1995 à ROUEN (76000)

Ablation du nœud atrio-ventriculaire associée à la stimulation de la zone de la branche gauche dans le traitement de la fibrillation atriale : Une expérience monocentrique

Présentée et soutenue publiquement le 02 octobre 2023 devant un jury composé de :

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SERMENT D'HIPPOCRATE

En présence des enseignants et enseignantes
de cette Faculté,
de mes chers condisciples
et selon la tradition d'Hippocrate,
je promets et je jure d'être fidèle aux lois de l'honneur
et de la probité dans l'exercice de la Médecine.

Je donnerai mes soins gratuits aux indigents,
et n'exigerai jamais un salaire au-dessus de mon travail.

Admis dans l'intérieur des maisons, mes yeux
ne verront pas ce qui s'y passe, ma langue taira
les secrets qui me seront confiés et mon état ne servira pas
à corrompre les mœurs ni à favoriser le crime.

Respectueux et reconnaissant envers mes Maîtres,
je rendrai à leurs enfants
l'instruction que j'ai reçue de leurs parents.

Que les hommes et les femmes m'accordent leur estime
si je suis fidèle à mes promesses.
Que je sois couvert d'opprobre
et méprisé de mes confrères et consœurs
si j'y manque.

REMERCIEMENTS

À Madame la Professeur Anne BERNARD, mon maître et présidente du jury

Merci de me faire l'honneur de juger ce travail et de présider ce jury de thèse.
Recevoir ton enseignement au laboratoire d'échographie ou en garde est une chance.
Merci pour ta bienveillance, ta patience et ton accompagnement tout au long de l'internat.

À Monsieur le Docteur Arnaud BISSON, mon maître et directeur de thèse

Merci de me faire l'honneur de juger ce travail, et de l'avoir dirigé.
Merci pour tes conseils, tes corrections et ta présence sans faille tout au long de ce projet.
Tu es un exemple de rigueur et de pragmatisme.
J'ai hâte de poursuivre ton enseignement en rythmologie.

À Monsieur le Professeur Dominique BABUTY, mon maître et juge

Merci de me faire l'honneur de juger ce travail.
Je ne saurai vous remercier assez pour tout ce que vous m'avez apporté pendant ces années d'études, notamment en me transmettant votre passion de la cardiologie et de la rythmologie.
Travailler à votre contact en tant qu'interne a été un plaisir, avec des conseils avisés, une méthode et une qualité de formation infaillible.
Merci, merci pour tout.

À Monsieur le Docteur Nicolas CLEMENTY, mon maître et juge

Merci de me faire l'honneur de juger ce travail.
Merci pour ta sympathie, ton humour, et la qualité de la formation que tu m'as délivrée.
Avoir pu participer au déroulement du staff ECG pendant un an à tes cotés aura été un privilège.
Tu as toute ma reconnaissance.

À Monsieur le Docteur Alexandre BODIN, mon maître et juge

Merci de me faire l'honneur de juger ce travail.
Merci pour ta disponibilité, ta gentillesse et pour la formation que tu m'as délivré depuis le tout début de mon internat.
Je suis heureux de poursuivre prochainement ton enseignement en rythmologie.

Merci à tous ceux qui m'ont accompagné et qui ont participé à ma formation.

Au **Professeur Fauchier**, merci pour la qualité de votre formation en cardiologie et votre enseignement de la rigueur dans l'exercice de la médecine. Avoir pu travailler à vos coté comme référent des internes a été un plaisir, merci de m'avoir fait confiance. Vous avez participé à mon désir de poursuivre mon parcours en rythmologie, merci de m'y accueillir prochainement.

Au **Professeur Angoulvant**, merci pour votre bienveillance, votre disponibilité et votre accompagnement pendant ces années d'internat.

Au **Dr Pierre**, merci pour vos enseignements, vos discussions toujours argumentées et enrichissantes.

Au **Dr Semaan**, merci pour ta gentillesse, ta confiance et ton soutien dans les situations d'urgence.

Au **Dr Darwiche**, merci pour tes conseils, ta motivation contagieuse et ton investissement dans le stage d'USCI.

Au **Dr Genet**, merci pour ta bonne humeur et pour ton aide pour mes premières gardes de chef.

Aux **Dr Saint-Etienne, Dr Clerc, Pr Ivanes**, merci pour votre bienveillance, et votre accueil en salle de cathétérisme.

Au **Dr Dion, à Nicolas, à Antonin**, merci pour votre accueil et votre formation pendant le semestre aux explorations fonctionnelles cardiaques.

À **Iris, à Mathias et à Jérémie**, merci d'avoir été mes internes lors de mon premier stage d'externat en cardiologie, et de m'avoir donné gout à cette spécialité.

Aux équipes paramédicales, **aux secrétaires et aux assistantes de recherche clinique** de l'hospitalisation complète de cardiologie, de l'hospitalisation de semaine de cardiologie, de l'USCI, du bloc de rythmologie, du laboratoire d'explorations fonctionnelles cardiaques et de la coronarographie : merci pour tous ces moments passés à vos côtés. Travailler avec vous à la bonne prise en charge des patients est un plaisir et participe à la qualité de notre formation.

À l'équipe du service de chirurgie vasculaire pour votre bienveillance pendant mon semestre dans votre service. Merci au **Dr Martinez, au Dr Marchand, au Dr Nauta, au Dr Loreille** et bien évidemment au **Dr Robson**.

À l'équipe de cardiologie de l'hôpital d'Orléans, merci pour votre accueil. Ce semestre dans votre service aura été un plaisir et un point de progression dans ma formation. Une nouvelle page de cette formation devrait s'écrire à vos côtés, je l'espère. Merci au **Dr Goralski, au Dr Gamet, au Dr Nguyen, au Dr Malmare**.

À l'équipe de réanimation médicale de l'hôpital d'Orléans, merci de m'avoir accueilli dans cette période particulière du COVID. J'ai beaucoup appris à vos côtés, et ces connaissances me serviront encore, au service des patients les plus graves. Merci particulier au **Professeur Barbier, au Dr Boulain, au Dr Muller** (avec qui je découvre Paris différemment), **au Dr Desgrouas, au Dr Mathonnet, au Dr Bretagnole, au Dr Skarzynski**.

À l'équipe de réanimation cardiovasculaire et chirurgie cardiaque du CHU pour ce dernier semestre passé dans votre service. Merci aux **chirurgiens cardiaques, aux anesthésistes, aux cardiologues et aux réanimateurs** pour votre accueil et tout ce que vous m'avez appris !

À **Maëva**, merci pour ta présence et ton soutien tout au long de mon internat. Avoir pu évoluer à tes côtés, dès mon premier semestre, aura été une chance, et m'aura permis d'acquérir une méthode de travail rigoureuse. Merci de ta confiance et de ta disponibilité, particulièrement lors du stage d'USCI ou lors de mes premières gardes de chef. Ta présence rassure et oblige à donner le meilleur de soi-même. Tu es un modèle de médecin, tu as mon admiration.

Merci à mes amis, et co-internes,

À **Charlène**, notre alsacienne préférée et ma copine de promo : Merci pour cette année passée à Orléans, d'abord à l'USIC puis en réanimation. Découvrir les traditions de ton pays à tes cotés (Rivella, saucisse de viande, gougloups ou autres méneuleu…) provoque toujours étonnement et hilarité, mais nous a permis de passer un excellent week-end dans ta capitale, Strasbourg. Bientôt co-docteurs juniors, hâte de poursuivre cette aventure !

À **Ahma… Oups ! Au Dr (Professeur…?) Abou Hamed** ! : D1, externat, internat, notre amitié s'écrit sur presque l'ensemble de nos études médicales. Toujours là pour nous faire rire ou nous emmener dans des histoires folles, tu es une personne très attachante. Travailler avec toi en HS ou à la référence des internes a été parfait, et je suis heureux que nous ayons pu partager ça ensemble.

À **Claire**, la personne la plus surprenante que j'ai pu rencontrer. Toujours très expressive, vraie, tu nous étonnes au quotidien. Merci également d'être notre copine de chat, et de garder notre enfant Simone à chacune de nos vacances. Bon, et sans rancune pour les puces hein !

À **Ines, Marine, Ivann** (mon binome des box <3) : mes coupaings de l'USCI ! Quel semestre incroyable en votre compagnie, où s'entremêlaient entraide, partages et coups de rats : abandon de 71245, transfert d'appels sauvages (même à Maëva…), affichage au staff ECG… Oula j'ai vraiment fait tout ça ? C'est HON-TEUX !

Au frate **Mickael** en échographie cardiaque, à **Samy** et son célèbre tir à l'aveugle en HS, à **Thibault** en HC, et à **Lisa** (qui m'a vu passer bien trop de temps sur ces remerciements…) en réanimation cardiovasculaire, merci d'avoir été de super co-internes. Merci également à tous mes autres co-internes pour votre bonne humeur et les bons moments passés avec vous : **Mathieu, Jean-Baptiste, Kassem, Thibault, Roxane, Marie, Sihame, Yassine, Lucille, Pierre, Paul, Younes, Alexandre, Constance, Lauriane, Dylan.**

Au grand frère **Pascal**, merci d'avoir été mon interne d'HS au début de ma D4 et de m'avoir aidé à confirmer mon choix de poursuivre en cardiologie. Merci de ton aide et de ta présence pendant cette année passée à Orléans, où staff ECG rimait avec petit déjeuner (Petits pains ça rimait moins bien). Tu m'as également aiguillé quand j'étais jeune référent des internes, j'ai hâte de travailler de nouveau avec toi.

À mes co-internes de réanimation médicale : **Ines, Chemsa, Fanny, Alice, Clément, William, Jonathan**, merci pour cet excellent semestre passé avec vous !

À **Gatien et Sophie**, merci pour le semestre en réanimation cardiaque : grâce à vous, je suis presque devenu anesthésiste !

À mes amis d'externat **Jean, Aude, Esther** : Merci pour tous ces moments passés ensemble, à Tours, Angers, Lamballe et ailleurs. La distance nous sépare un peu plus qu'à la belle époque, mais vous retrouver, et voir que notre amitié est restée la même, est toujours un vrai plaisir.

Merci à ma famille

À **mes parents**, merci d'avoir toujours été présents à mes côtés, d'avoir toujours donné le maximum pour que je ne manque de rien. Votre éducation, tous les moments passés ensemble depuis l'enfance, tout ce que vous m'avez offert, c'est ce qui m'a permis d'avoir toutes mes chances dans l'accomplissement de ces études. Je vous aime.

À **ma sœur**, merci ta complicité et tout ce que tu as apporté à ma vie. Tu as soutenu ton mémoire de fin d'études il y a quelques mois, c'est maintenant à mon tour de soutenir ma thèse. Même si on se voit moins, je pense souvent à toi, et sais que l'on pourra toujours compter l'un sur l'autre. Je t'embrasse fort.

À **mes grands-parents**, merci pour tout ce que vous m'avez apporté depuis l'enfance. Le temps est passé, je passe aujourd'hui ma thèse, mais je sais que malgré cela vous gardez en mémoire ce tout-petit, qui courait, jouait et chantait les chansons de Joe Dassin dans la maison de Thézan-lès-Béziers. Je vous embrasse fort.

À **mes oncles, tantes, cousins et cousines**, merci tous les moments de vie passés ensembles.

À mes beaux-parents, **Valérie et Patrick**, pour m'avoir accueilli auprès de vous, pour votre bienveillance et votre gentillesse.

À **mon frère Corentin** (oui, oui, il a réussi à se glisser là) : le hasard de notre rencontre il y a maintenant 10 ans, à la sortie d'un cours de pré-rentrée de la prépa de la PACES, pourrait faire croire au destin : nous sommes devenus inséparables. Que d'aventures passées ensembles, une thèse ne suffirait pas à toutes les raconter : café smash, recettes pompettes, balades en forêt, grands buffets, gourdinpiades, jeu de rôle… La liste est longue, je n'aurais pas pu rêver meilleur compère pour les vivre !

Enfin, à **Laurine**, qui partage ma vie depuis bientôt 5 ans. Merci pour ta confiance, ton soutien et tout ce que tu m'apportes au quotidien. Vivre à tes cotés est une chance, et me permet de donner le meilleur de moi-même. Cette année a été riche pour nous : nous vivons maintenant dans notre chez-nous, nous nous sommes pacsés et nous sommes toujours les parents du petit chat le plus mignon. Je suis impatient de voir ce que la suite nous réserve, je sais que ça ne pourra être que merveilleux.

Ablation du nœud atrio-ventriculaire associée à la stimulation de la zone de la branche gauche dans le traitement de la fibrillation atriale : Une expérience monocentrique

Introduction : L'ablation du nœud atrio-ventriculaire (NAV) associée à l'implantation d'un pacemaker est un traitement efficace de la fibrillation atriale (FA) symptomatique. La stimulation ventriculaire droite permanente est pourvoyeuse d'asynchronisme cardiaque, pouvant aggraver les symptômes d'insuffisance cardiaques (IC). La stimulation de la zone de la branche gauche est une nouvelle technique de stimulation plus physiologique, moins à risque d'asynchronisme cardiaque.

Objectif : Évaluer la faisabilité, la sécurité et les résultats à 6 mois de l'ablation du NAV associée à une stimulation de la zone de la branche gauche chez des patients atteints de FA symptomatique.

Méthodes : Cette étude rétrospective monocentrique réalisée au CHRU de Tours a inclus consécutivement tous les patients ayant bénéficié d'une procédure d'ablation du NAV associée à une stimulation de la zone de la branche gauche. La procédure d'ablation du NAV, le suivi clinique, électrique et échocardiographique à l'inclusion et à 6 mois ont été étudiés et comparés aux données d'une cohorte appariée de patients ayant reçu une ablation du NAV et stimulation conventionnelle entre mars 2010 et février 2023.

Résultats : 75 procédures d'ablation du NAV et stimulation de la zone de la branche gauche ont été étudiées. La procédure d'ablation du NAV dans ce contexte était faisable, avec un taux de succès de 98,7% à la première ablation, et de 100% après 2 ablations, sans complication et notamment sans déplacement de sonde. Les paramètres électriques du pacemaker à l'implantation étaient bons, et stables à 6 mois, sans élévation de seuil de capture. A 6 mois, 4 (5%) patients ont été hospitalisés pour IC et 1 (1,3%) est décédé. Les patients présentaient une amélioration significative de la classe NYHA, des symptômes de palpitations et de la fraction d'éjection du ventricule gauche (FEVG) ($P \leq 0.0001$ pour tous). Après appariement à une cohorte de patient ayant eu une ablation du NAV et une stimulation conventionnelle, les données d'ablation du NAV et les complications de la stimulation étaient similaires. Les patients avec stimulation de la zone de la branche gauche avaient une amélioration significativement plus importante de la FEVG (+5.27±9.62% versus -0.48±14% ; $P = 0.01$) et avaient un taux d'hospitalisation pour insuffisance cardiaque semblant moins important (HR 0.34, 95% CI: 0.1-1.06; $P = 0.064$).

Conclusion : L'ablation du NAV associée à une stimulation de la zone de la branche gauche en traitement de la FA symptomatique est une procédure faisable, sûre et efficace. Le taux de complication et d'hospitalisation pour insuffisance cardiaque à 6 mois est comparable à celui de la stimulation conventionnelle et l'amélioration de la FEVG est significativement plus importante.
Mots-clés : Fibrillation atriale, ablation du nœud atrio-ventriculaire, stimulation de la zone de la branche gauche

Single center experience of efficacy and safety of atrioventricular node ablation after left bundle branch area pacing for the management of atrial fibrillation

Introduction: Atrioventricular node ablation (AVNA) with permanent pacing is an effective treatment of symptomatic atrial fibrillation (AF). Permanent right ventricular pacing is associated with cardiac dyssynchrony, which can worsen heart failure (HF) symptoms. Left bundle branch area pacing (LBBAP) is a recent pacing technique, more physiologic and less associated with cardiac dyssynchrony.

Objective: To evaluate feasibility, safety and outcomes at 6 months of AVNA associated with LBBAP in patients with symptomatic AF.

Methods: In this retrospective monocentric study of Tours University Hospital, we included all consecutive patients who received AVNA procedure with LBBAP. AVNA procedure, clinical follow-up, electrical and echographic data at baseline and 6 months were studied and compared to the data of a matched cohort of patients who received an AVNA procedure with conventional pacing between March 2010 and February 2023.

Results: 75 AVNA procedures and LBBAP were studied. AVNA in this context was feasible, with a success rate of 98.7% at first ablation, and 100% after 2 ablations, and without any complications, especially no lead dislodgement. Pacing electrical parameters at implant were good, and stable at 6 months follow-up, with no threshold rise. At 6 months, 4 (5%) patients were hospitalized for heart failure and 1 (1.3%) was deceased. Patients had a significative improvement in NYHA class, of palpitations symptoms, and left ventricular ejection fraction (LVEF) ($P \leq 0.0001$ for all). After matching with a cohort of patients with AVNA and conventional pacing, AVNA data and pacing complications were similar. Patients with LBBAP had a significative better improvement of LVEF (+5.27±9.62% versus -0.48±14% ; $P = 0.01$), and a lower rate of hospitalization for HF (HR 0.34, 95% CI: 0.1-1.06; $P = 0.064$).

Conclusion: AVNA with LBBAP in patients with symptomatic AF is feasible, safe and efficient. Complication and hospitalization for HF rate at 6 months is similar to AVNA with conventional pacing, and LVEF improvement is significantly more important.

Key word: Atrial fibrillation, atrioventricular node ablation, left bundle branch area pacing

Summary

Abbreviations

AF: Atrial fibrillation

AV: Atrio-ventricular

AVNA: Atrio-ventricular node ablation

CP: Conventional pacing

CPP: Cardiac physiologic pacing

CRT: Cardiac resynchronization therapy

CSP: Conduction system pacing

ESC: European society of cardiology

EHRA: European heart rhythm association

HF: Heart failure

IVCD: Intra ventricular conduction delay

LA: Left atrium / Left atrial

LBBAP: Left bundle branch area pacing

LBBB: Left bundle branch block

LBBP: Left bundle branch pacing

LFP: Left fascicular pacing

LV: Left ventricle / Left ventricular

LVEF: Left ventricular ejection fraction

LVSP: Left ventricular septal pacing

PICM: Pacing induced cardiomyopathy

PM: Pacemaker

RBBB: Right bundle branch block

RVP: Right ventricular pacing

Introduction

Atrial fibrillation (AF) is a very common disease, with an estimated prevalence of 8.8 million people in Europe [1], and 33 million people worldwide [2]. AF is associated with heart failure, strokes, and an increased all-cause mortality [3]. Whereas recent studies have shown that early rhythm control therapy lowers the risk of adverse cardiovascular outcomes [4], this strategy is not achievable for all patients. Indeed, a long history of uncontrolled AF or comorbidities such as hypertension, obesity, metabolic syndrome, sleep apnea induce abnormal left atrial substrate, decrease efficacy of rhythm control strategy and expose to a higher recurrence rate [5].

Atrioventricular node ablation (AVNA) with permanent ventricular pacing is a therapeutic strategy first described surgically in 1967 by Giannelli and al. [6]. The authors reported a case of surgical mitro-aortic valvular replacement associated with ligation of the AV node and permanent epicardial pacemaker implantation, in order to treat supraventricular tachycardias associated with a rheumatic heart disease. Surgical AVNA was also described to treat symptomatic drug resistant Wolf Parkinson White syndrome, in which cases, permanent pacemaker would not be needed [7]. Gallagher et al. [8] proposed in 1982 the first closed chest technique for AVNA, performed by delivering a direct-current shock to the conduction system through an intracardiac catheter positioned in the His bundle region. AVNA technique improved progressively and is now performed is most cases using intra cardiac catheters delivering radiofrequency energy via a transvenous route. Over the last decades, studies have shown its efficacy in patients with AF, unsuitable for rhythm control therapy, and persistent heart failure (HF) symptoms despite optimal medical treatment. In 1997, a first randomized multicenter study showed superiority in controlling symptoms and improving quality of life of the AVNA and pacing strategy (so called ‘pace and ablate’ strategy) versus pharmacological treatment in symptomatic paroxysmal AF [9]. Garcia et al. showed a reduction in cardiovascular mortality and thromboembolic events following AVNA and pacing versus pharmacological strategy in patients with AF, even in patients with paroxysmal AF [10]. In 2020, the European Society of Cardiology (ESC) guidelines for the management of AF recommended that AVNA should be considered to control heart rate in patients unresponsive or intolerant to intensive rate and rhythm control strategy, and not eligible for rhythm control by atrial ablation, accepting that these patients will become pacemaker dependents (Class IIa, level of evidence B) [5].

Unfortunately, cardiac dyssynchrony, caused by a delay in the timing of electrical and mechanical activation between the right and left ventricles, is reported in 50% of cases during permanent right ventricular pacing (RVP), and can worsen HF symptoms [11]. So called pacing induced cardiomyopathy (PICM) is characterized by decline in left ventricular ejection fraction (LVEF) or HF due to chronic RVP. Definition varies across different studies, but most retain following criteria : decrease in LVEF < 50%, and/or absolute drop of at least 10% from baseline, and/or new-onset HF symptoms after pacemaker implantation [12]. Male sex, advanced age, high RVP burden, coronary artery disease, pre-existing AF, baseline prolonged paced QRS duration are the risk factors for the development of PICM [12]. Cardiac physiologic pacing (CPP) [13], including biventricular pacing (BVP) and, more recently, physiological pacing techniques such as conduction system pacing (CSP), has emerged as a good alternative to RVP to prevent this evolution. Studies shown that CPP reduces the risk of cardiac dyssynchrony [14–16], and is also effective to reverse its consequences [14,17]. The APAF-CRT [18] trial studied the effect of AVNA associated with BVP in patients with permanent symptomatic AF. The trial was stopped prematurely for efficacy at interim analysis, with a significative reduction in mortality (HR 0.26; 95%CI 0.10-0.65), and reduction in a combined endpoint of death or hospitalizations for HF (HR 0.40; 95%CI 0.22-0.73) versus pharmacological treatment. Following those results, 2021 ESC guidelines on cardiac pacing and CRT recommended using BVP rather than RV pacing in patients with LVEF < 40% (Class I, level of evidence B) or in patients with LVEF 40-49% (Class IIa, level of evidence C) [19].

CSP is a pacing technique that implies direct activation of conduction system of the heart by electric stimulus. His bundle or its majors' branches are directly paced, and the level of conduction system capture is determined by the anatomical position of the pacing lead, the paced QRS morphology and the potential to QRS interval. Different entities are described, the most frequent being His bundle pacing (proximal or distal), left bundle branch area pacing (LBBAP) including left bundle branch and left fascicular pacing (LBBP and LFP), and the right bundle branch pacing [20]. **Figure 1** displays those different entities.

CSP concept was first described by Narula et al. in 1970 [21]. In their study, the team accomplished His bundle pacing on several patients, after positioning the pacing lead on anatomical His bundle position, and after recording His bundle potential. Unfortunately, stable CSP could not be achieved in most patients because of anatomical variations and catheter movements, and the technique did not develop at this time. Last decade has seen a

resurgence of CSP with numerous studies on His bundle pacing at first [22]. However, this technique was still associated with inherent limitations. The implant technique is challenging, targeting a small zone, with anatomical variations, and harder in patients with dilated heart disease. Follow-up is also fraught with numerous issues such as oversensing of atrial or His potentials, high capture thresholds associated with premature battery depletion or complete loss of capture [23], which may result in higher generator replacements and leads revision [24].

In 2017, Huang et al. first described a new pacing technique leading for LBBP [25]. By positioning the pacing lead deep in the interventricular septum, ~1–2 cm toward the RV apex from the distal His bundle potential, it was possible to capture the pre-divisional left bundle branches with simultaneous activation of its fascicles. New entities were then described and more appropriate definitions were given such as LBBAP which involves capture of the subendocardial area on the left side of the interventricular septum. LBBAP includes LBBP or LFP when simultaneous conduction system capture is achieved and left ventricular septal pacing (LVSP) when it is not [20]. Since the first description, several studies have shown promising clinical perspectives [26–28] and 43 are underway at the time of writing this manuscript (https://clinicaltrials.gov/ct2/results?term=LBBAP+OR+LBBP). LBBAP seems to be the best approach for physiological pacing, with easier and shorter implantations procedures than His bundle pacing [29]. Pacing directly the left bundle branch area in order to prevent cardiac dyssynchrony was recently shown effective, with improvement in LVEF and a preservation of global longitudinal strain [30]. LBBAP also seems to be a perfect fit for patients with permanent pacing indication, but we lack of long-term clinical data. Moreover, questions remain as to the safety of AVNA under these conditions in particular regarding distance between ablation and pacing sites.

The objective of this study was therefore to explore our initial center experience of LBBAP associated with AVNA as a treatment of AF. We firstly assessed the feasibility, the safety, and the outcome of AVNA associated with LBBAP in patients with resistant symptomatic AF, and secondly compared clinical follow-up with conventional pacing.

Methods

Study design and data collection

We conducted a retrospective monocentric observational study of patients admitted to the cardiology department at the University Hospital of Tours for pacing and AVNA procedure from May 2010 to February 2023. Patients had to be 18 years or older and have a history of uncontrolled ventricular rate, HF or palpitations due to AF despite optimal rhythm control strategy including AF ablation or pharmacological therapy. All patients with successful LBBAP implantation prior to AVNA were consecutively included from the first AVNA procedure performed in our department. For comparison, a cohort of consecutive patients implanted with conventional pacemakers including RVP and BVP before AVNA was built. The choice of RVP or BVP was based on underlying LV dysfunction and comorbidities, following currently available guidelines at the moment of the inclusion. The choice of LBBAP or conventional pacing was based on the operator preference. Patients implanted with leadless pacemaker were not included in this study. Information on history of AF, comorbidities, medications, echocardiographic data were collected from hospital medical reports. Follow-up data were collected also from hospital medical reports and from cardiologist's surgery. Index date of each patient was the date of first AVNA. As data were collected retrospectively, anonymized and patients not involved in the conduct of the study, ethical consent was not needed.

Left bundle branch area pacing strategy

LBBAP was performed in a standard fashion [20,31]. We used a SelectSecure pacing lead (Medtronic, model 3830) and a delivery sheath (Medtronic, C315His, C315S10 or C304His SelectSite). No back up pacing lead was implanted. Initial pacing site location at right surface of ventricular septum was assessed using distal His bundle potential location, by advancing the catheter 1-1,5cm towards right ventricular apex using RAO 30° view. Then, counter clockwise torque was then applied in LAO 30-45° view in order to direct the sheath progressively through the ventricular septum, where the left bundle branch is expected to be located. Further criteria measured on per-operative electrocardiograms were used to confirm LBB capture according to recent studies [20,32–34]. We included all consecutive patient undergoing successful LBBAP procedure as defined by the latest guidelines [20] algorithm, as

shown in **Figure 2**. All patients with a Qr/QR/qR paced QRS morphology in V1 were considered as success. We then classified the LBBAP patients in 3 categories:

- Confirmed LBBP if V6RWPT (V6 R-wave peak times) < 75ms (native narrow QRS or isolated right bundle branch block (RBBB)) or V6RWPT < 80ms (Left bundle branch block (LBBB), Intra-ventricular conduction delay (IVCD), RBBB + fascicular block, wide escape rhythm, asystole) or V6-V1 interpeak interval > 44ms
- Likely LBBP if V6RWPT < 85ms (native narrow QRS or isolated RBBB) or V6RWPT < 100ms (LBBB, IVCD, RBBB + fascicular block, wide escape rhythm, asystole) or V6-V1 interpeak interval > 33ms
- Left ventricular septal (LVS) pacing if previous criteria were not fulfilled.

Conventional pacing strategy

All consecutive RVP or BVP were included in the conventional pacing strategy. Patients were implanted with right ventricular in standard technique. For BVP-pacing, the coronary sinus lead was targeted to the basal-mid-portions of the free wall when feasible. The atrial port of the device was excluded.

AVNA procedure

AVNA was performed up to 14 days after pacemaker implantation. Using a femoral venous access, a 4-mm non-irrigated ablation catheter was advanced through a long 7F introducer. Radiofrequency ablation was performed in the AV junction area (compact AV node and proximal His-bundle area) until AV block was achieved. Ablation was performed at 60 W with temperature control of 60°C. In patients with failure to achieve AV block from the right side, femoral arterial access was obtained, and the ablation catheter was advanced retrogradely under the aortic cusps and a His bundle recording was mapped. After AV block was achieved, all patients were monitored for 10 minutes to ensure no return of conduction through the AV node. AVNA was deemed successful when there was no AV conduction after the waiting period. We also performed several procedures of ablation if atrioventricular conduction reappeared. After achieving a complete atrioventricular bloc, the pacemaker was systematically programmed on VVIR 75bpm.

Outcomes

All patients were followed 6 months at least. Acute and chronic outcomes were analyzed. The primary outcome was a composite of all cause death and/or hospitalization due to HF. Secondary outcomes were total mortality, hospitalization for HF, evolution of NYHA classification and evolution of LVEF. AVNA procedures were analyzed in both groups with collection of procedure time, fluoroscopy time, procedure outcomes and complications. Electrical parameters including ventricular sensing, pacing thresholds and impedance were compared at implant and follow-up in the LBBAP group. Threshold rise was defined as an elevation superior to 1V during follow-up. Acute and late pacing complications such as lead dislodgment, pocket hematoma, pericardial effusion, severe tricuspid regurgitation, and lead infection were tracked and collected using hospital records.

Statistical analysis

Qualitative variables are described as counts and percentages and quantitative variable as means±standard deviations (SD). Comparisons were made using Chi2 tests for categorical variables and the Student's t-test for continuous variables. Due to the non-randomized nature of the study, treatment selection bias and potential confounding were reduced by using propensity score matching to account for significant differences in baseline characteristics and year of implantation. Propensity scores were calculated using logistic regression with underlying cardiac disease as the dependent variable. The propensity score included 5 covariates: LVEF (by quartile), age (by quartile), CHA_2DS_2VASc [35] score, kidney failure (defined as estimated glomerular filtration rate $\leq 30 mL/m^2$) and hospitalization for HF within the year preceding the procedure. For each patient with a LBBAP, a propensity score-matched patient with a conventional pacing was selected (1:1) using the one-to-one nearest neighbor method (with a caliper of 0.05 of the SD of the propensity score on the logit scale) and no replacement. We assessed the distributions of demographic data and comorbidities in the LBBAP and conventional pacing cohorts with standardized mean differences. A standardized mean difference of 0.10 or less indicated a negligible difference between the means of the two cohorts. For the outcome's analysis, in the matched cohorts, the incidences of outcomes between the two groups during follow-up were estimated using Mantel–Haenszel weighing. Cox regression analysis was used and results were expressed as hazard ratio (HR) and 95%

confidence intervals (95% CI). Survival analysis was also performed, using Kaplan Meyer curve and Log Rank test. All comparisons with $P < 0.05$ were considered statistically significant. All analyses were performed using STATA version 16.0 (Stata Corp, College Station, TX).

Results

A total of 308 AVNA and transvenous pacing procedures were realized between May 2010 and February 2023 at the university Hospital of Tours (**Figure 3**). 82 were implanted with LBBAP devices, 97 with BVP and 129 with RVP. Overall, 65 patients were not included in the analysis: 58 did not complete follow-up (0 in LBBAP group and 58 in conventional group) and 7 patients had LBBAP failure (8.5% of LBBAP procedures).

Baseline characteristics

Table 1 and 2 show the baseline characteristics for all included patients. In the LBBAP group, mean age was 77.4±8.2 years and 46.7% were male. 73.3% presented symptoms of HF, 29.3% were hospitalized for HF within the year preceding inclusion and mean CHA_2DS_2VASc score was 4.01±1.45. 42.7% had previous electrical cardioversion and 34.7% had previous AF catheter ablation. Mean heart rate was 93±27 bpm, mean QRS width was 115±25ms with 13.3% of LBBB morphology. Mean LVEF was 49.64±14.48% and 21.3% had medium/severe mitral regurgitation. 28% had coronary heart disease and 12% had dilated cardiomyopathy.

In the conventional pacing group, patients were a bit older with mean age 79.7±8.99 years (P = 0.06), and had a significantly higher CHA_2DS_2VASc score (4.51±1.5; P = 0.02), higher NYHA classification (2.8±0.7; P = 0.02), a higher rate of HF symptoms (85.7% ; P = 0.002) and hospitalization for HF in the past year (56% ; P = 0.0001). LVEF was also significantly lower in this group, with a mean LVEF of 43.18±14.62% (P = 0.002). There was no significative difference concerning coronary heart disease and dilated cardiomyopathy.

LBBAP QRS morphology

After a mean procedure duration for LBBAP implantation of 51.13±25.45min and a mean fluoroscopy time of 10±19.91min, acute mean paced QRS duration was 133.6±1.9ms and V6RWPT was 87.7±15.3ms. 24 (32%) patients had a V6RWPT<80ms or <75ms (when native QRS were narrow or isolated RBBB). 36 (48%) patients had V6RWPT<85ms and 5 (7%) patient had a V6RWPT<100ms when native QRS showed LBBB, IVCD or RBBB + fascicular block. Acute mean V6-V1 interpeak interval was 38.5±17.8ms: 51 (68%) patients had a V6-V1 interpeak interval>33ms and 36 (48%) had a V6-V1 interpeak interval>44ms.

According to the European Heart Rhythm Association (EHRA) algorithm for LBBAP pacing recently published, 43 (57%) patients had confirmed LBBP, 17 (23%) were likely to have LBBP and 15 (20%) LVSP [20]. At 6 months, the mean paced QRS duration was 134.4±2ms and V6RWPT was 78.6±1.8ms.

LBBAP electrical parameters

Acute capture threshold was low (mean 0.7±0.45V), R wave amplitude high (mean 9.15±5.07mV) and mean impedance was 640±251Ohm (**Figure 4**). These parameters were found to be stables during follow-up, with a mean impedance of 420±90 Ohm, mean capture threshold of 0.64±0.27V and mean R wave amplitude of 13.4±6.5mV at 6 months. There was no threshold rise. Battery longevity was estimated at 6 months at 11.5±2.36 years for a mean ventricular pacing rate of 99±0.5%.

AVNA procedure characteristics in LBBAP group

Mean delay between pacemaker implantation and AVNA was 2.69±0.28 days. This delay was inferior or equal to a day for 29 patients (38.67%) and inferior to a week for 71 (94.67%). Immediate success was achieved for 98.7% patients (1 failure). 2 patients needed a second intervention for AV reconnection, which was successful in both cases. Mean procedure duration was 29.23±18.36min and fluoroscopy time was 8.28±10.28min. Over all procedures, none was associated with any acute complication, particularly there was no lead dislodgment or loss of capture.

Outcomes and complications in LBBAP group

At 6 months, 4 (5%) patients were hospitalized for HF, and 1 (1.3%) died few days after hospitalization for HF. As shown in **Table 3** LBBAP after AVNA resulted at 6 months in a significant improvement in NYHA class (mean of differences: -0.96±0.96; $P < 0.0001$), palpitations (-95%; $P < 0.0001$), and LVEF (mean of differences: +5.22±9.55; $P = 0.0001$). LVEF improvement was non-significantly different between the different LBBAP subtypes (+7.06±8.10% for confirmed LBBP; +5.96±9.66% for likely LBBP; +2.25±8.86% for LVSP). **Figure 5** shows the evolution of LVEF for each individual.

Pacing complications occurred in 9 patients (12%). Early complications were 2(2.7%) lead dislodgements and 3(4%) pocket hematomas. 4 patients (5.3%) had severe tricuspid regurgitations.

Procedural characteristics and outcomes comparison in matched cohorts

After propensity score matching, 68 patients were distributed in either LBBAP or conventional pacing group (44 (65%) of RVP and 24 (35%) of BVP) (**Figure 3**). **Figure 6** shows the standardized percentages of bias across covariates before and after matching. Baseline characteristics in the two populations were well matched (**Table 4**). We noted a significative higher rate of SAOS (20.6% versus 4.4%; P = 0.004) in the LBBAP group. There was also a significative difference in anticoagulant therapy with a significantly higher rate of vitamin K antagonists in the conventional group (52.2% versus 11.8%; P <0.0001).

Comparison of AVNA procedural characteristics between LBBAP and Conventional pacing group after matching is summarized in **Table 5**. Procedures seemed to be shorter in LBBAP group, but not significantly. There was no significant difference on fluoroscopy time and ablation success rate. AVNA was performed earlier in the Conventional pacing group, with 75% of patients having their ablation 1 day or less after pacemaker implantation versus 43% (P < 0.0001).

6 months outcomes for matched patients are summarized in **Table 6**. The primary combined outcome occurred in 4 patients (5.88%) in the LBBAP group and 11 patients (16.18%) in the Conventional pacing group (HR 0.34, 95% CI: 0.1-1.06; P = 0.064). Survival analysis was close to show significant difference (Log rank p-value = 0.051) (**Figure 7**). Survival curve for all-cause mortality is displayed on **Figure 8.** For secondary endpoints, all-cause mortality occurred in 1 patient (1.47%) in the LBBAP group and in 2 patients (2.94%) in the Conventional pacing group (HR 0.49, 95% CI 0.04-5.6; P = 0.57) and hospitalization for HF occurred in 4 patients (5.88%) in the LBBAP group and 11 patients (16.18%) in the Conventional pacing group (HR 0.34, 95% CI: 0.1-1.06; P = 0.064).

After 6 months, improvement in LVEF was significantly higher in the LBBAP group (+5.27±9.62% versus -0.48±14% ; P = 0.01) as shown in **Figure 9**. This difference was mainly driven by the RVP subgroup (RVP: -4.59±11.98, P < 0.0001; BVP: +6.76±13.71, P = 0.59). Evolution in NYHA class is displayed in **Figure 10**. At 6 months, NYHA class was significantly lower in LBBAP group (1.62±0.67 versus 1.88±0.83; P = 0.049), but the

comparison of mean differences from baseline was not significative (-0.7±0.83 versus -0.98±-0.98; $P = 0.08$).

There was also no significant difference regarding complication rates (**Table 7**).

Discussion

From this initial single center experience, we investigated the feasibility, safety and clinical outcomes of AVNA associated with LBBAP in patients with symptomatic AF refractory to treatments. This study gives up-to-date information and may give interest to physician with regard to LBBAP in this population.

First, AVNA procedure performed in patients with LBBAP is safe: neither lead dislodgement nor threshold rise occurred in our 75 LBBAP patients and procedural characteristics were similar to the conventional pacing group. These results are consistent with previous studies evaluating AVNA in patients after LBBAP. In a retrospective single center study comparing 50 patients with LBBAP and 50 patients with HBP referred for AVNA procedures, 100% AVNA were successful in the LBBAP group, who showed fewer acute and chronic lead related complication than HBP [36].

Then, LBBAP procedure is feasible, with 91.5% success rate in our cohort. Electrical parameters at baseline were good, with a low capture threshold (mean 0.7±0.45V). These parameters were stable during follow up with no capture threshold rise. Early complications associated with LBBAP were few, and in a similar proportion when compared with conventional pacing, with no significant difference.

Since its description in literature, multiple studies on LBBAP have shown that it is a safe and stable pacing method, and our work contributes to this observation. In the MELOS European multicenter registry [26], which is currently the biggest registry on LBBAP, 2,500 patients were prospectively included to receive LBBAP. Implantation success rate was 89.6% and 78.5% had LBB capture (21.5% had LVSP). At 6 months, follow-up capture threshold and R wave amplitude were stable, with no significant difference when compared to acute parameters. Acute and late complications occurred in 11.7% of the procedures, and 8.25% were directly attributed to the transseptal route of the pacing lead (3.67% intraprocedural perforation into the LV cavity, 1.5% lead dislodgement, 0.43% acute coronary syndrome).

We found in our study a higher rate of severe tricuspid regurgitation in the LBBAP group when compared to matched patients in the Conventional pacing group. It's fair to say that we've been paying more attention to the tricuspid valve in recent years because of the recent development of percutaneous techniques. It is possible that echocardiographic reports of patients included in the conventional pacing group lack information about tricuspid valve when compared to more recently included patients. More studies focusing on

echocardiographic data and especially on tricuspid valve are needed to assess the real incidence of tricuspid regurgitation with this new pacing technique.

Finally, clinical outcomes were not significantly different regarding mortality or hospitalization for HF when compared to conventional pacing. However, a significant improvement of LVEF was observed. In another nonrandomized study form Vijayaraman et al comparing AVNA associated with CSP (84 HBP and 46 LBBAP) versus conventional pacing (57 BVP and 56 RVP), CSP was safe and associated with less death events or hospitalization for HF and a significant improvement in LVEF (from 46.5±14.2% to 51.9±11.2% ; $P = 0.02$) after a mean follow-up of 27±19 months, though LVEF improvement was not significant in the LBBAP subgroup (from 46.9±15.1% to 50.1±12.9%, $P = 0.2$) [37]. Interestingly, among patients with conventional pacing, the authors reported an improvement of LVEF for the BVP subgroup (26.7±10.5% at baseline versus 33.8±15.5 at follow up) but a trend to decrease for the RVP subgroup (50.3±12.0% at baseline versus 47.7±13.2 at follow up). These results are consistent with our experience and bring good confidence in the outcomes associated with LBBAP and AVNA.

Numerous case series and randomized studies have proven the effectiveness of AVNA with permanent pacing as a therapeutic option for improving symptoms, quality of life and morbidity in patients with uncontrolled AF, resistant to other treatments [9,10,18,37]. Moreover, multiples RCTs have demonstrated the interest of BVP compared to RVP in this indication, in order to prevent the risk of PICM [18,38,39]. In PAVE study, follow-up LVEF was significantly greater in the BVP group when compared to the RVP group [38]. In another randomized multicenter study, RVP resulted in significant increase in LA volume and worsening of LVEF [39]. In APAF CRT trial, BVP and AVNA was superior to pharmacological therapy in reducing HF, hospitalization, and mortality [18]. Our study also supports the value of maintaining ventricular synchrony when the pace and ablate strategy is chosen for rate control in AF: significant difference in LVEF evolution between both groups was mainly driven by the detrimental effect of RVP (LVEF difference from baseline: -4.59±11.98).

However, despite its reference state for resynchronization, BVP is also fraught with downsides, due to the use of more complex devices and material, leading to a high rate of procedural and follow-up complications [19]. First, the implantation requires extra skill in positioning the LV lead into the coronary sinus branches, especially in HF subjects with enlarged LV [40]. Then, LV leads have a particular propensity for complications such as

dislodgement and coronary vein dissection or perforation [41]. In a nationwide registry, LV leads were more commonly associated with complications compared with RV leads (4.3% versus 2.2%) [42]. In a meta-analysis of 25 BVP trials, 3.2% procedures were associated with mechanical complications and 6.2% were associated with other lead-related problems [43]. Significant diaphragmatic stimulation (up to 5% procedures), and generator battery depletion are also a concerns, and expose the patient to a higher hospitalization rate for re-intervention [44,45]. In a retrospective study comparing BVP and RVP devices, 50% (versus 10%) of patients with BVP device underwent surgical revision for battery depletion in the four years of implantation, and 14% (versus 4%) for unanticipated events such as LV lead dislodgement or lead infection [46]. Finally, by requiring more leads and specific material, BVP procedures are longer, and at higher cost compared with RVP [47]. For those multiple reasons, some operators can be reluctant to propose BVP to every patient especially in frail and comorbid patients, even in this particular context of AVNA when cardiac synchronicity preservation is an absolute requirement.

In 2017, Huang et al. probably found a good compromise for AVNA issues, with a new pacing method, that could fit every single patient. After all, LBBAP seems to have the benefits of both RVP and BVP, without their side effects. As described earlier, LBBAP prevents the risk of PICM [30], which is the most concern with RVP. However, LBBAP seems also interesting when compared to BVP. First studies on resynchronization using LBBAP look promising. Wang et al. compared LBBAP and BVP as resynchronisation therapy in patients with non-ischemic cardiomyopathy and HF with reduced LVEF [27]. The study demonstrated a significantly greater LVEF improvement in the LBBAP group, with similar improvement in functional status and similar safety in both procedures. In another study assessing the outcomes of LBBAP in patients who failed conventional BVP because of LV lead complication or who were non responders to BVP, LBBAP resulted in a significative improvement in LVEF with stable pacing threshold and good clinical outcomes [48]. Finally, in a recent international multicenter observational study including 1778 patients who underwent BVP or LBBAP for CRT indication (981 BVP and 797 LBBAP), LBBAP group had a greater improvement of LVEF (13%±12% versus 10%±12%; $P < 0.001$) and a significant reduction of a composite criteria of death or heart failure hospitalization (20.8% versus 28%; HR: 1.495; 95% CI: 1.213-1.842; $P < 0.001$) [49].

In May 2023, The Heart Rhythm Society (HRS) published new guidelines on CPP [13] that enlightens us on matters discussed here (**Figure 11**). In patients with AF undergoing

AVNA with LVEF ≤ 50%, CRT with BVP is reasonable to improve quality of life, LVEF and mortality (Grade 2aB). In the same indication, HBP or LBBAP lead implantation may be reasonable (Grade 2bB). Moreover, in patients with LVEF > 50%, undergoing AVNA, it may be reasonable to implant an LBBAP lead (Grade 2bB). These new guidelines show us that lines are moving and LBBAP could be the pacing first choice for all patients undergoing AVNA for AF treatment: a one lead fits all strategy. Ongoing randomized studies are therefore eagerly awaited to raise the grade of recommendation to its highest level.

Limitations

Our study suffers several limitations inherent to its design. Patients were non-randomized between pacing techniques. As expected, baseline characteristics of our 3 paced populations were substantially different. This was well balanced after propensity matching. Nonetheless, this resulted in a reduction of our population and a loss of statistical power.

Additionally, follow-up data, and particularly LVEF or NT-proBNP were not available in all patients.

LBBAP being a recent technic, inclusion of the 75 patients in this group began in June 2020. These patients therefore benefited from more up to date care than the patients implanted with conventional technics, the majority of whom were included earlier.

Concerning the LBBAP group, criteria used for assessment of LBB capture are in constant evolution and some were not used to classify our patients. We did not record per procedural QRS transition during threshold test or programmed stimulation, or LBB potential recording. We essentially used the Qr/QR/qR, the RW6PT and the V1-V6 criteria, with the cutoff provided in the EHRA algorithm [20], which gave us 60/75 patients (80%) with confirmed or likely to have LBBP and 15/75 (20%) with LVSP. The rate of true LBBP patients may therefore be higher. Additionally, LBBAP failure happened in 7 procedures (8.5%). This results are consistent with those observed in the MELOS European registry as describe earlier [26].

Conclusion

In this single center first experience study of permanent AF patients, AVNA after LBBAP was a feasible and safe procedure. LBBAP electricals parameters were good and stable during follow up with no threshold rise and complication rate was low. In the matched analysis with conventional pacing, mortality or hospitalization for HF rate were similar at 6 months, and LBBAP group was significantly associated with a better LVEF improvement.

Tables

Table 1. Baseline characteristics

	Ablation + RVP (n=90)	**Ablation + BVP (n=78)**	**Ablation + LBBAP (n=75)**	***P*-value LBBAP *vs* RVP**	***P*-value LBBAP *vs* BVP**
Age (years)	78.71±9.91	80.83±7.72	77.4±8.22	0.36	0.01
Male sex	35 (38.9)	36 (46.2)	35 (46.7)	0.32	0.95
CHA2DS2VASc	4.34±1.73	4.71±1.17	4.01±1.45	0.19	0.001
Body mass index	28.51±6.7	30.95±22.7	28.61±5.94	0.92	0.39
History of AF					
Previous electrical cardioversion	25 (27.8)	15 (19.5)	32 (42.7)	0.05	0.003
Previous catheter ablation	17 (18.9)	8 (10.4)	26 (34.7)	0.02	0.0003
Hospitalisation for heart failure in last year	45 (50)	49 (62.8)	22 (29.3)	0.01	<0.0001
Symptoms					
NYHA	2.64±0.74	2.97±0.6	2.55±0.84	0.48	0.0004
Palpitations	29 (33.7)	26 (33.3)	21 (28)	0.5	0.49
Standard electrocardiogram					
Heart rate (b.p.m)	106±29	104±24	93±27	0.002	0.006
QRS width (ms)	105±26	122±29	115±25	0.05	0.13
Bundle branch block	28 (31.1)	42 (53.8)	28 (37.3)	0.4	0.04
Left bundle branch block	16 (17.8)	30 (38.5)	10 (13.3)	0.44	0.0003
Echocardiogram					
Ejection fraction	52.1±11.33	33.55±11.31	49.64±14.48	0.24	<0.0001
Ejection fraction <= 35%	18 (20)	48 (61.5)	20 (26.7)	0.31	<0.0001
Severe aortic stenosis	4 (4.4)	4 (5.1)	2 (2.7)	0.55	0.44
Medium/severe mitral insufficiency	5 (5.6)	41 (52.6)	16 (21.3)	0.002	<0.0001
Medical history					
Heart failure	68 (76.7)	75 (96.2)	55 (73.3)	0.72	0.001
Hypertension	68 (75.6)	63 (80.8)	49 (65.3)	0.15	0.03
Diabetes	24 (26.7)	12 (15.4)	12 (16)	0.1	0.92
Stroke / transient ischaemic attack	12 (13.3)	8 (10.3)	8 (10.7)	0.6	0.93
Coronary heart disease	23 (25.6)	27 (34.6)	21 (28)	0.73	0.38
Dilated cardiomyopathy	6 (6.7)	25 (32.1)	9 (12)	0.24	0.003
SAOS	4 (4.4)	5 (6.4)	14 (18.7)	0.003	0.02
Pulmonary disease	18 (20)	12 (15.4)	7 (9.3)	0.06	0.26
Renal insufficiency	21 (23.3)	16 (20.5)	6 (8)	0.01	0.03
Biology					
NT-proBNP	2752±5440	10721±16564	3216±3644	0.68	0.001
Medications					
Betablockers	68 (76.4)	65 (84.4)	54 (72)	0.52	0.06
Digoxin	10 (11.2)	12 (15.6)	7 (9.3)	0.69	0.25
Class III antiarrhythmic drugs	22 (24.7)	17 (22.1)	24 (32)	0.3	0.17
Class I antiarrhythmic drugs	4 (4.5)	0 (0)	3 (4)	0.88	0.08
Diuretics	60 (67.4)	57 (74)	47 (62.7)	0.53	0.16
ACEi or ARBs	54 (60.7)	54 (70.1)	48 (64)	0.66	0.42
Mineralocorticoid antagonist	7 (7.9)	14 (18.2)	10 (13.3)	0.26	0.42
Vitamin K antagonists	51 (57.3)	42 (53.8)	9 (12)	<0.0001	<0.0001
Direct oral anticoagulants	35 (39.3)	35 (44.9)	65 (86.7)	<0.0001	<0.0001
Antiplatelet agents	7 (7.8)	12 (15.4)	1 (1.3)	0.06	0.002

Values are n (%) or mean±SD.

ACEi: Angiotensin-converting enzyme inhibitors; ARBs: angiotensin receptor blockers

Table 2. Baseline characteristics before matching

	Ablation + Conventional pacing (n=168)	**Ablation + LBBAP (n=75)**	***P*-value**
Age (years)	79.7±8.99	77.4±8.22	0.06
Male sex	71 (42.3)	35 (46.7)	0.52
CHA2DS2VASc	4.51±1.5	4.01±1.45	0.02
Body mass index	29.63±16.15	28.61±5.94	0.6
History of AF			
Previous electrical cardioversion	40 (24)	32 (42.7)	0.004
Previous catheter ablation	25 (15)	26 (34.7)	0.0005
Hospitalisation for heart failure in last year	94 (56)	22 (29.3)	0.0001
Symptoms			
NYHA	2.8±0.7	2.55±0.84	0.02
Palpitations	55 (34)	21 (28)	0.46
Standard electrocardiogram			
Heart rate (b.p.m)	106±27	93±27	0.0001
QRS width (ms)	114±29	115±25	0.08
Bundle branch block	70 (41.7)	28 (37.3)	0.53
Left bundle branch block	46 (27.4)	10 (13.3)	0.02
Echocardiogram			
Ejection fraction	43.18±14.62	49.64±14.48	0.002
Ejection fraction <= 35%	66 (39.3)	20 (26.7)	0.06
Severe aortic stenosis	8 (4.8)	2 (2.7)	0.45
Medium/severe mitral insufficiency	46 (27.4)	16 (21.3)	0.32
Medical history			
Heart failure	144 (85.7)	55 (73.3)	0.02
Hypertension	131 (78)	49 (65.3)	0.04
Diabetes	36 (21.4)	12 (16)	0.33
Stroke / transient ischaemic attack	20 (11.9)	8 (10.7)	0.78
Coronary heart disease	50 (29.8)	21 (28)	0.78
Dilated cardiomyopathy	31 (18.5)	9 (12)	0.21
SAOS	9 (5.4)	14 (18.7)	0.001
Pulmonary disease	30 (17.9)	7 (9.3)	0.09
Renal insufficiency	37 (22)	6 (8)	0.01
Biology			
NT-proBNP	8012±14262	3216±3644	0.01
Medications			
Betablockers	133 (80.1)	54 (72)	0.16
Digoxin	22 (13.3)	7 (9.3)	0.39
Class III antiarrhythmic drugs	39 (23.5)	24 (32)	0.17
Class I antiarrhythmic drugs	4 (2.4)	3 (4)	0.5
Diuretics	117 (70.5)	47 (62.7)	0.25
ACEi or ARBs	108 (65.1)	48 (64)	0.87
Mineralocorticoid antagonist	21 (12.7)	10 (13.3)	0.88
Vitamin K antagonists	93 (55.7)	9 (12)	<0.0001
Direct oral anticoagulants	70 (41.9)	65 (86.7)	<0.0001
Antiplatelet agents	19 (11.3)	1 (1.3)	0.01

Values are n (%) or mean±SD.

ACEi: Angiotensin-converting enzyme inhibitors; ARBs: angiotensin receptor blockers

Table 3. 6 months outcomes in the LBBAP group.

	Baseline (n=72)	At 6 months (n=63)	Mean of differences*	*P**
NYHA	2.55±0.84	1.57±0.67	-0.96±0.96	<0.0001
Palpitations	21 (28)	1 (1.37)	-20 (-95)	<0.0001
Ejection fraction (%)	49.64±14.48	53.48±13.50	+5.22±9.55	0.0001
-LBBP confirmed	48.05±15.2	52.15± 13.99	+7.06±8.10	0.001
-LBBP confirmed or likely	49.08±14.51	53.35± 13.58	+5.96±9.66	0.0001
-LVSP	52.15±14.66	53.93± 13.75	+2.25±8.86	0.4

Values are n (%) or mean±SD.

*Mean of difference and paired t test calculated for patients having both ejection fraction at baseline and at M6 (n=60)

Table 4. Baseline characteristics after matching

	Ablation + Conventional pacing (n=68)	**Ablation + LBBAP (n=68)**	***P*-value**
Age (years)	75.75±10.4	77.59±8.54	0.17
Male sex	26 (38.2)	32 (47.1)	0.3
CHA2DS2VASc	4.01±1.55	4.13±1.3	0.63
Body mass index	30.52±19.14	28.6±5.47	0.43
History of AF			
Previous electrical cardioversion	24 (35.3)	29 (42.6)	0.4
Previous catheter ablation	18 (26.5)	22 (32.4)	0.46
Hospitalisation for heart failure in last year	24 (35.3)	22 (32.4)	0.72
Symptoms			
NYHA	2.58±0.68	2.62±0.83	0.75
Palpitations	26 (39)	18 (27)	0.121
Standard electrocardiogram			
Heart rate (b.p.m)	98±26	93±27	0.25
QRS width (ms)	108±26	115±25	0.15
Bundle branch block	19 (27.9)	25 (36.8)	0.27
Left bundle branch block	12 (17.6)	9 (13.2)	0.48
Echocardiogram			
Ejection fraction	49.78±12.34	48.91±14.53	0.71
Ejection fraction <= 35%	11 (16.2)	17 (25)	0.21
Severe aortic stenosis	2 (2.9)	2 (2.9)	1
Medium/severe mitral insufficiency	13 (19.1)	16 (23.5)	0.53
Medical history			
Heart failure	57 (83.8)	55 (80.9)	0.65
Hypertension	47 (69.1)	45 (66.2)	0.72
Diabetes	13 (19.1)	11 (16.2)	0.66
Stroke / transient ischaemic attack	8 (11.8)	6 (8.8)	0.58
Coronary heart disease	15 (22.1)	21 (30.9)	0.25
Dilated cardiomyopathy	10 (14.7)	9 (13.2)	0.81
SAOS	3 (4.4)	14 (20.6)	0.004
Pulmonary disease	5 (7.4)	6 (8.8)	0.76
Renal insufficiency	5 (7.4)	6 (8.8)	0.76
Biology			
NT-proBNP	3348±5105	3449±3736	0.93
Medications			
Betablockers	51 (76.1)	50 (73.5)	0.73
Digoxin	9 (13.4)	7 (10.3)	0.58
Class III antiarrhythmic drugs	13 (19.4)	22 (32.4)	0.09
Class I antiarrhythmic drugs	4 (6)	2 (2.9)	0.4
Diuretics	38 (56.7)	46 (67.6)	0.21
ACEi or ARBs	40 (59.7)	45 (66.2)	0.44
Mineralocorticoid antagonist	8 (11.9)	9 (13.2)	0.82
Vitamin K antagonists	35 (52.2)	8 (11.8)	<0.0001
Direct oral anticoagulants	31 (46.3)	59 (86.8)	<0.0001
Antiplatelet agents	12 (17.6)	9 (13.2)	0.48

Values are n (%) or mean±SD.

ACEi: Angiotensin-converting enzyme inhibitors; ARBs: angiotensin receptor blockers

Table 5. Comparison of AVNA procedural characteristics between LBBAP and conventional pacing group after matching.

	Ablation + conventional pacing (n=68)	Ablation + left bundle branch-pacing (n=68)	*P*
Procedural characteristics			
Procedure duration, min	36.6±22	29.7±19	0.06
Fluoroscopy time, min	9.6±13	8.5±11	0.6
Successful ablation	66(97)	68(99)	0.6
Complications			
Need for redo	0	2(3)	0.5
Per procedural pacing lead dislodgment	0	0	-
Timing after implantation			
Number of days	1.56±1.6	2.7±2.6	0.003
Timing≤1 day	51(75)	29(43)	<0.0001
Timing≤1 week	67(99)	64(94)	0.37

Values are n (%) or mean±SD.

Table 6. 6 months outcomes in matched cohorts.

	Ablation + conventional pacing (n=68)	Ablation + left bundle branch-pacing (n=68)	*P*
Primary outcomes			
Hospitalization for heart failure	11 (16,18)	4 (5.88)	0.055
Death from any cause	2 (2.94)	1(1.47)	0.56
Ejection fraction			
M6 ejection fraction	49.2±12	53.1±14	0.11
Mean of differences from baseline	-0.48±14	+5.27±9.62	0.01
NYHA			
M6 NYHA	1.88±0.83	1.62±0.67	0.049
Mean of differences from baseline	-0.70±0.83	-0.98±0.98	0.08
-3 classes improvement	1(1.5)	3(5)	0.096
-2 classes improvement	8(12)	18(27)	
-1 class improvement	35(52)	24(36)	
-No difference	16 (24)	17(26)	
-1 class worsening	7(10)	4(6)	

Values are n (%) or mean±SD.

Table 7. 6 months pacing complications in matched cohorts.

	Ablation + conventional pacing (n=68)	Ablation + left bundle branch-pacing (n=68)	*P*
All complications:	10 (14.7)	7 (10.3)	0.6
-Lead dislodgment	3 (4.4)	2 (2.9)	1
-Severe tricuspid regurgitation	1 (1.5)	4 (5.9)	0.37
-Pocket hematoma	3 (4.4)	2 (2.9)	1
-Pericardial effusion	2 (2.9)	0	0.49
-Device infection	1 (1.5)	0	1

Values are n (%) or mean±SD.

Figures

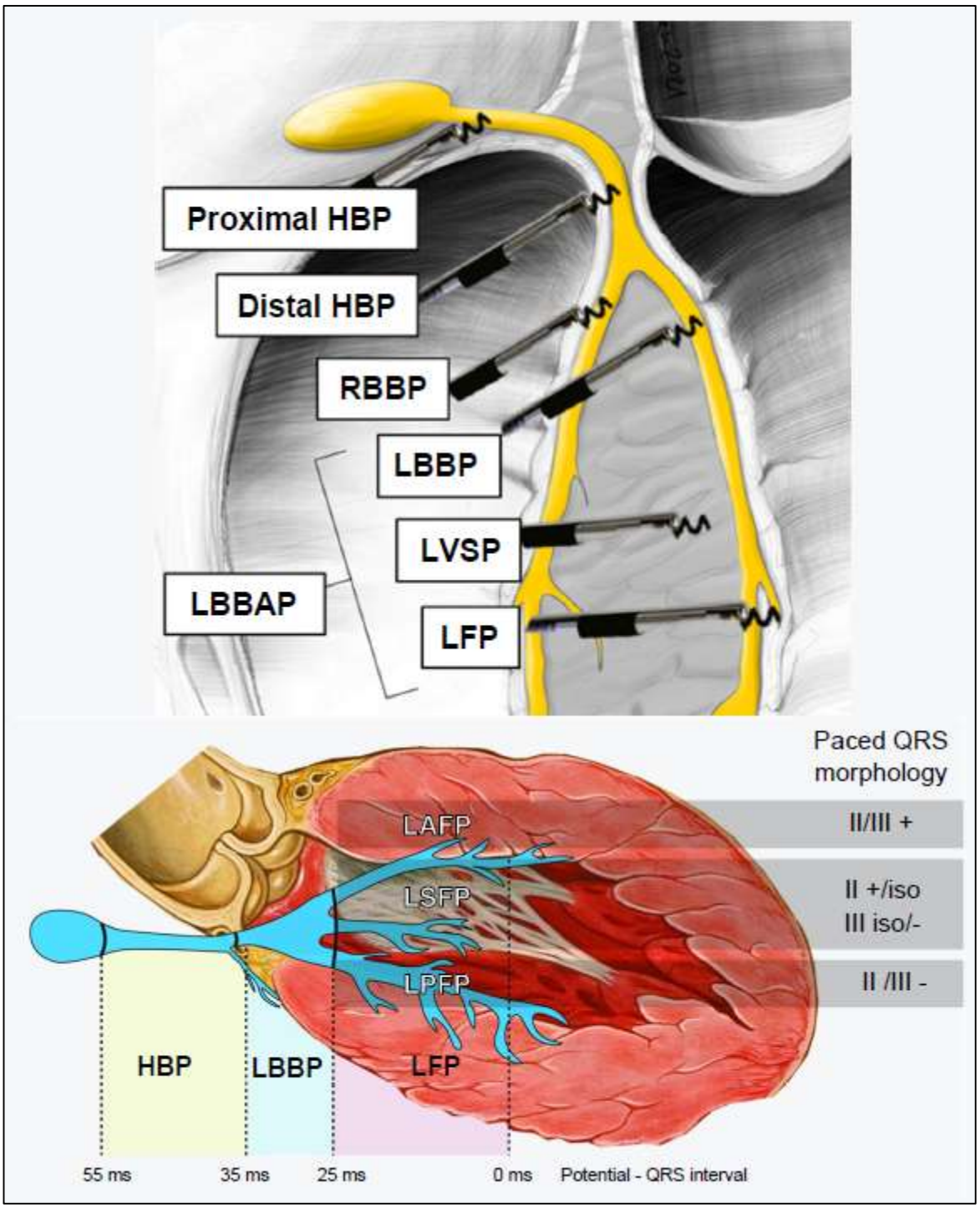

Figure 1. Representation of the different entities in conduction system pacing [20].

HBP: His Bundle Pacing; RBBP: Right bundle branch pacing; LBBAP: Left bundle branch area pacing; LBBP: Left bundle branch pacing; LVSP: Left Ventricular septal pacing; L(A/S/P)FP: Left (anterior/septal/posterior) fascicular pacing.

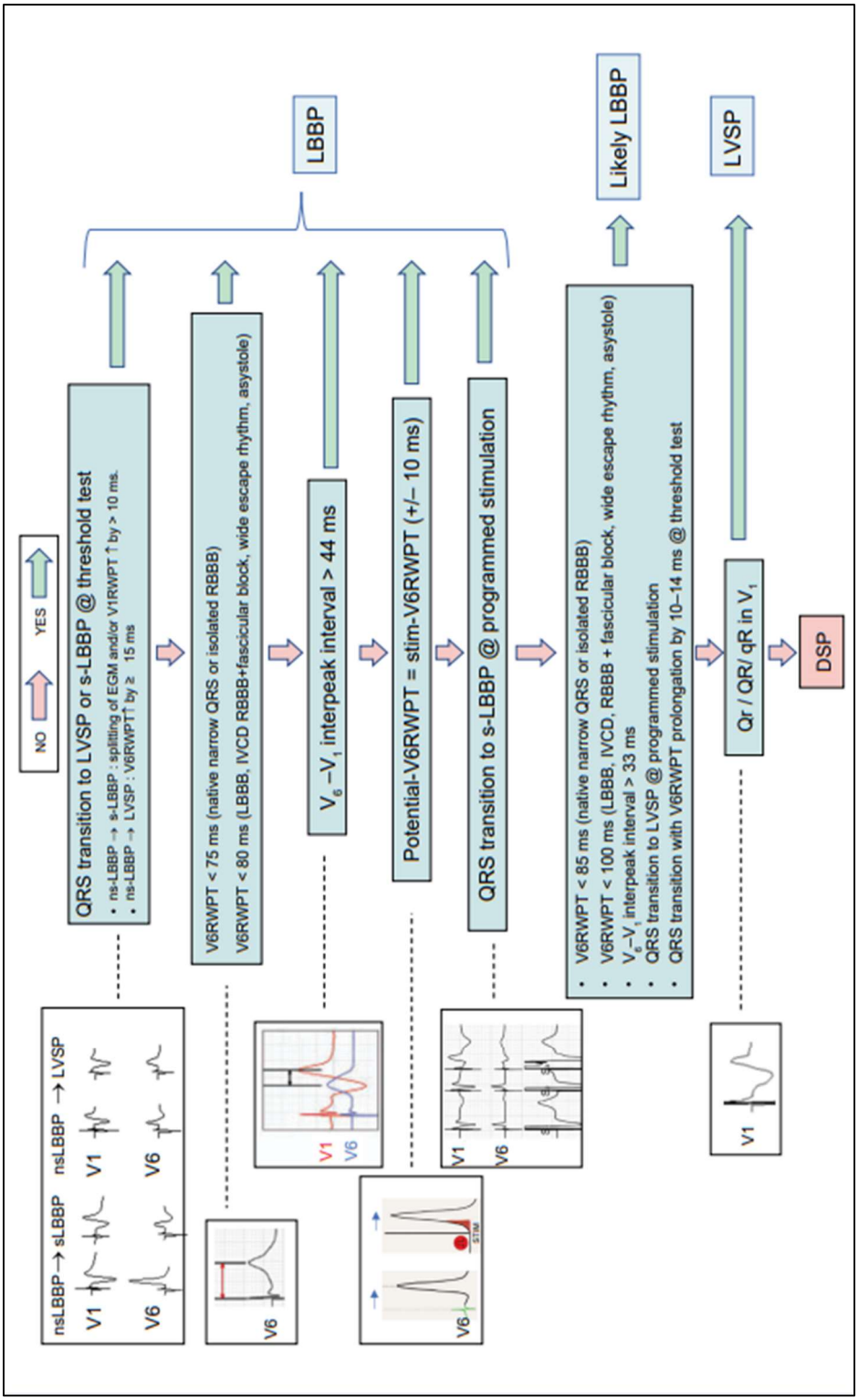

Figure 2. EHRA algorithm used to assess left bundle branch area pacing [20].

DSP: deep septal pacing; IVCD: intra-ventricular conduction delay; LBBAP: left bundle branch area pacing; LBBB left bundle branch block; ns-LBBP: non-selective left bundle branch pacing; RBBB: right bundle branch block; RBBP: right bundle branch pacing; RWPT: R-wave peak time; s-LBBP: selective left bundle branch pacing.

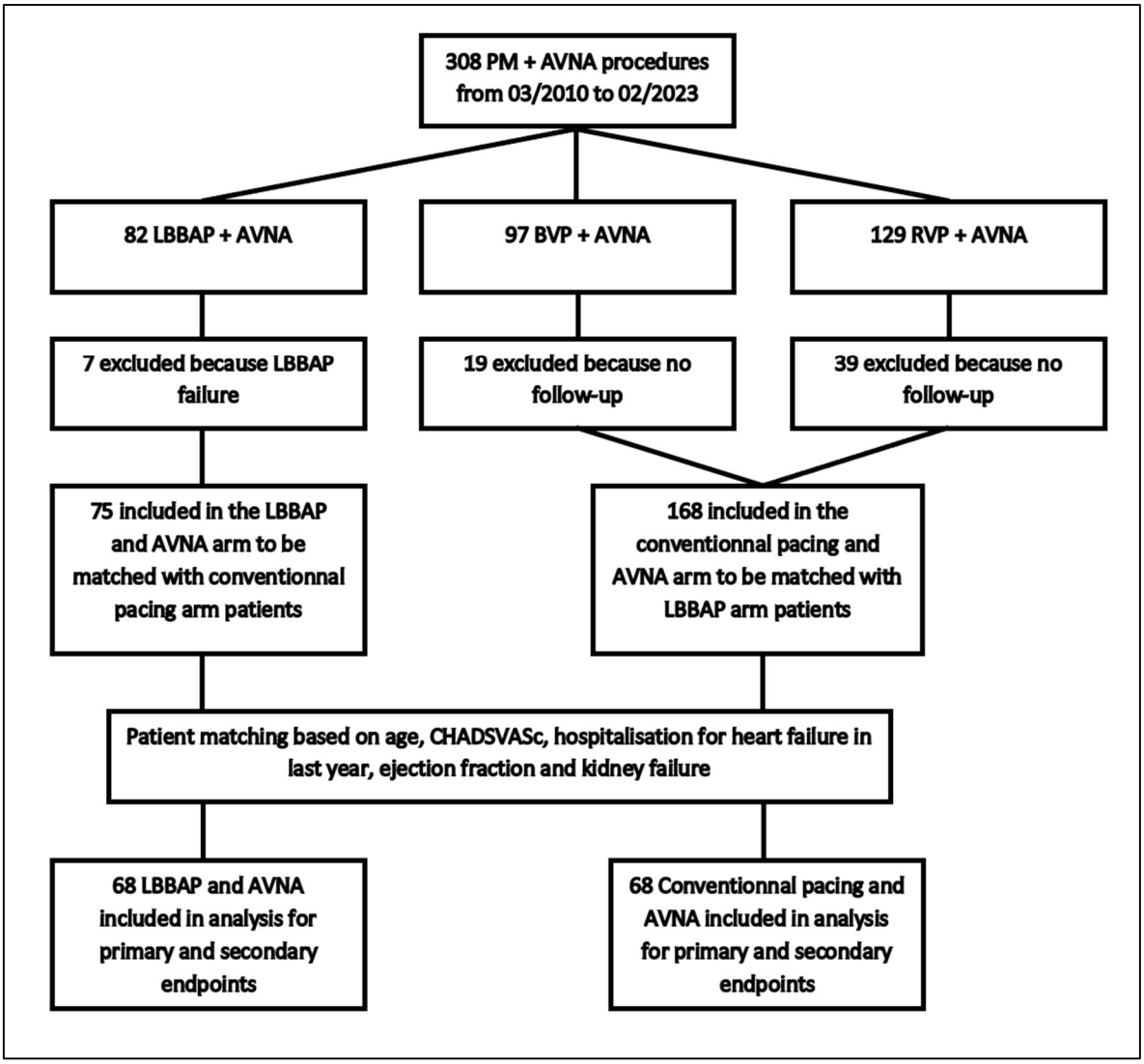

Figure 3. Flow chart of the study population.

AVNA: Atrio ventricular node ablation; BVP: Biventricular pacing; LBBAP Left bundle branch area pacing; PM: Pacemaker; RVP: right ventricular.

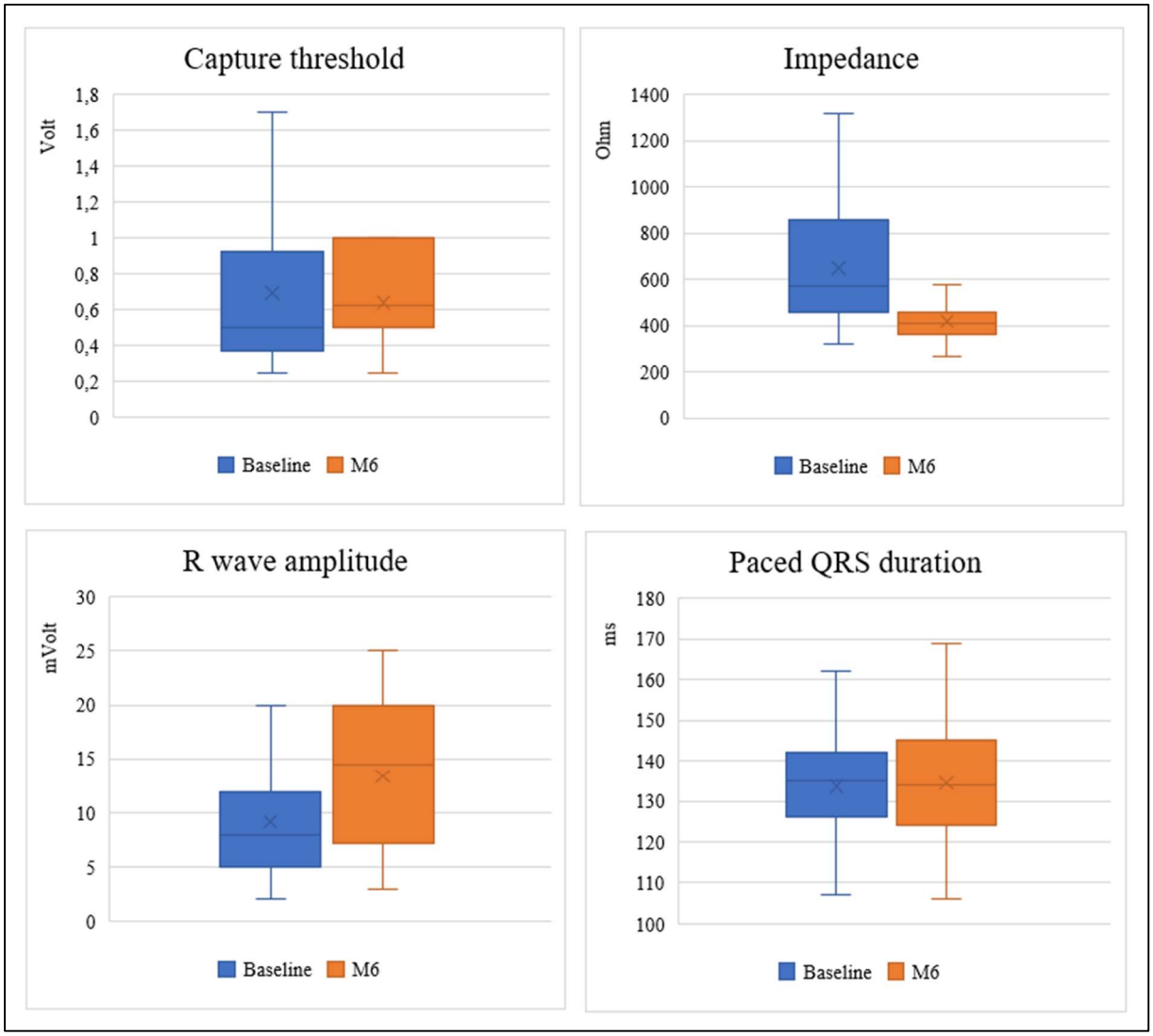

Figure 4. Evolution of electrical parameters (capture threshold, impedance, R wave amplitude and paced QRS duration) in non-matched LBBAP cohort.

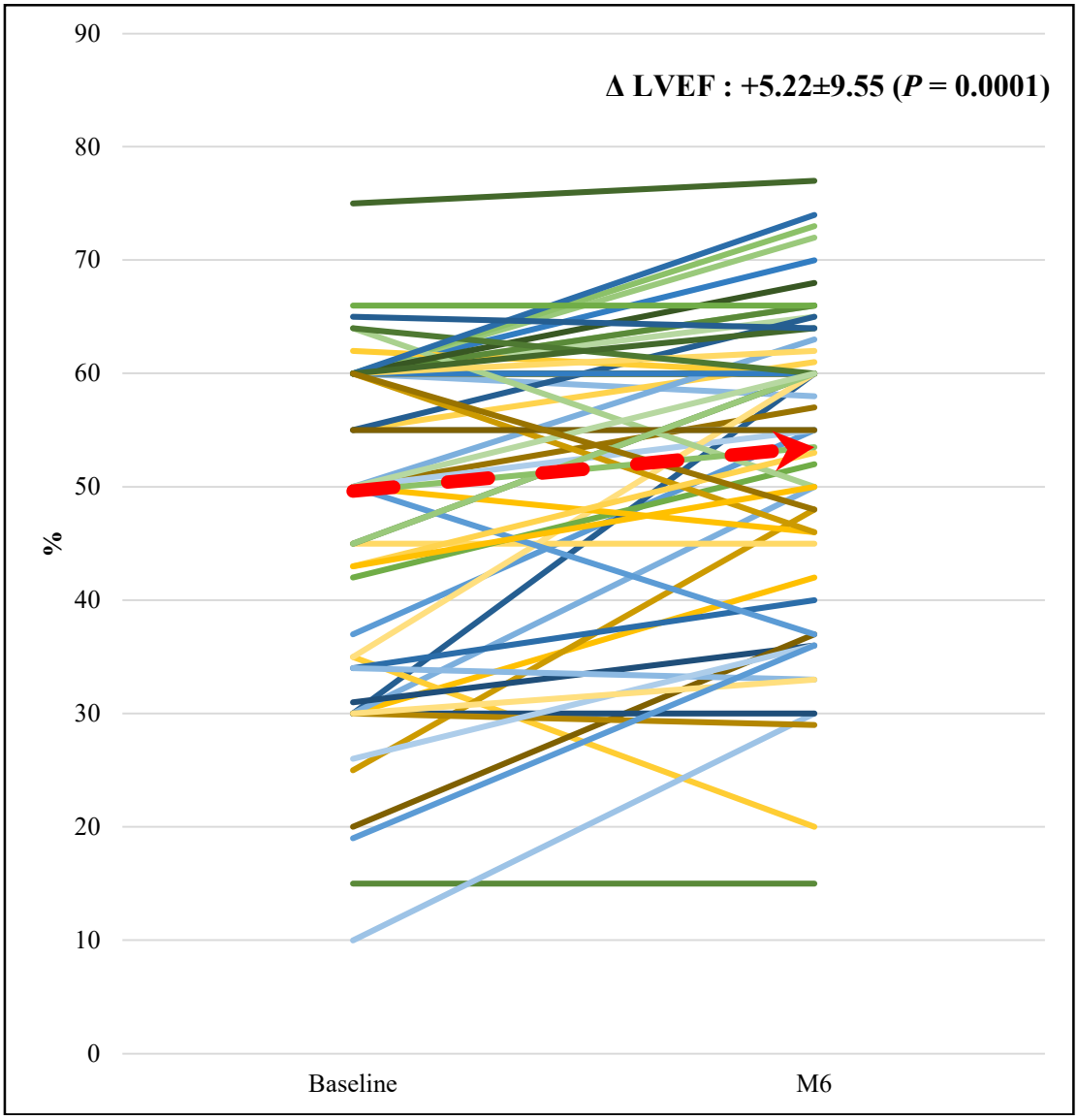

Figure 5. Evolution of left ventricular ejection fraction in non-matched LBBAP cohort.
Each string refers to an individual. Red arrow represents mean LVEF evolution.
LVEF: Left ventricular ejection fraction

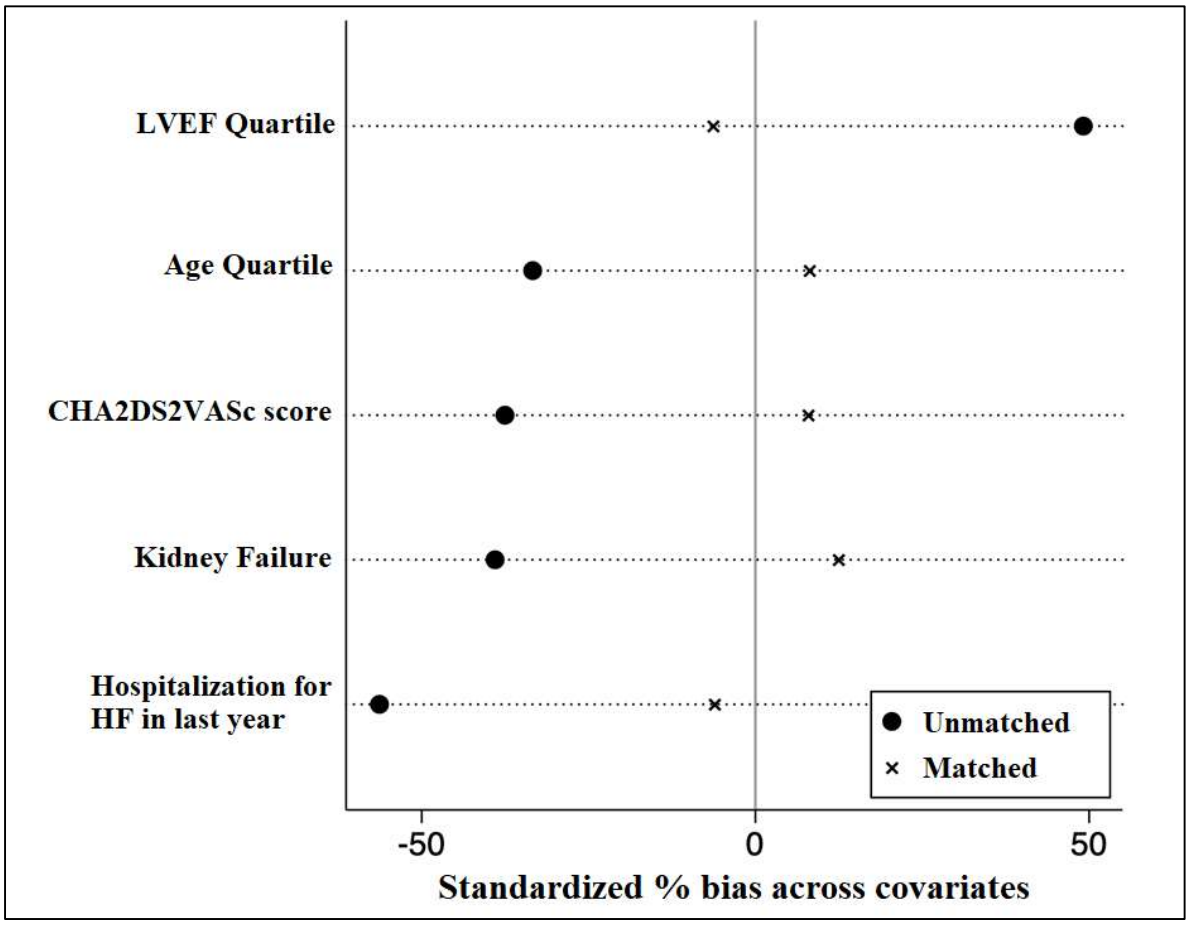

Figure 6. Standardized percentages of bias across covariates in unmatched and matched populations.

LVEF: Left ventricular ejection fraction; HF: Heart failure.

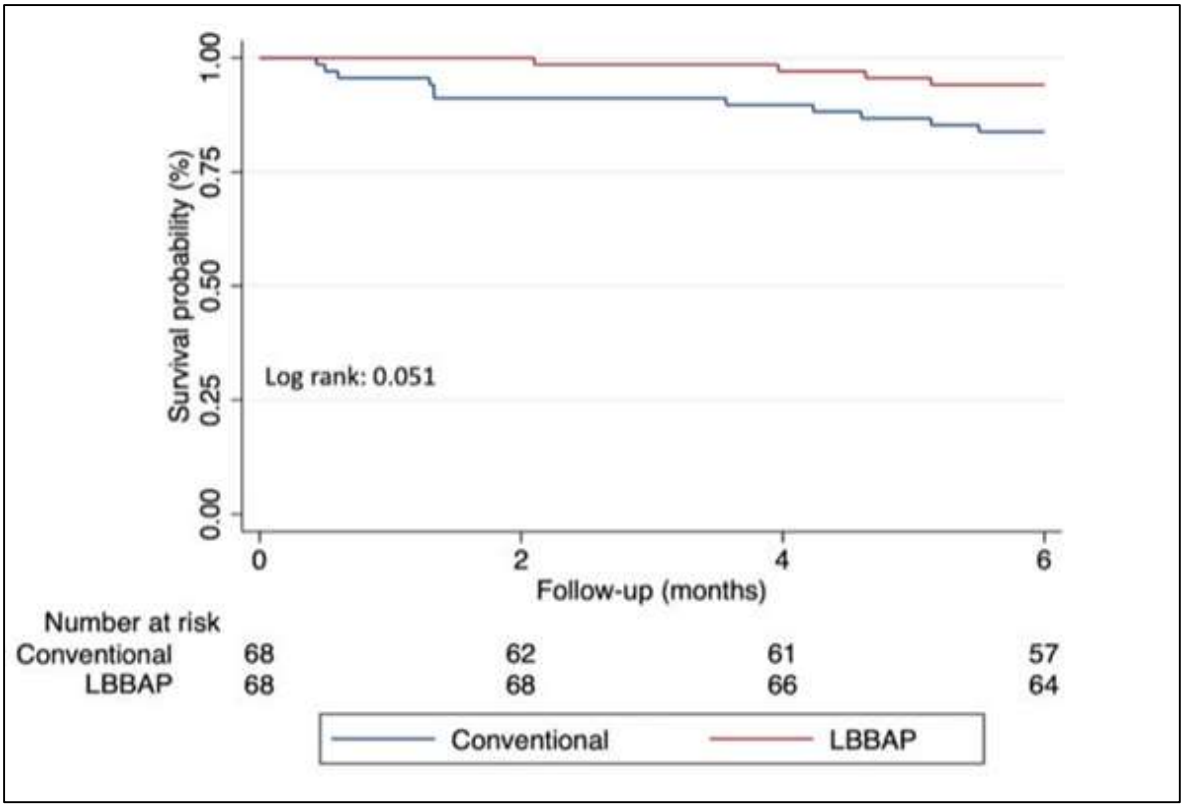

Figure 7. Incidence for combined endpoint (all cause death and hospitalization for heart failure) in matched populations

LBBAP: Left bundle branch area pacing.

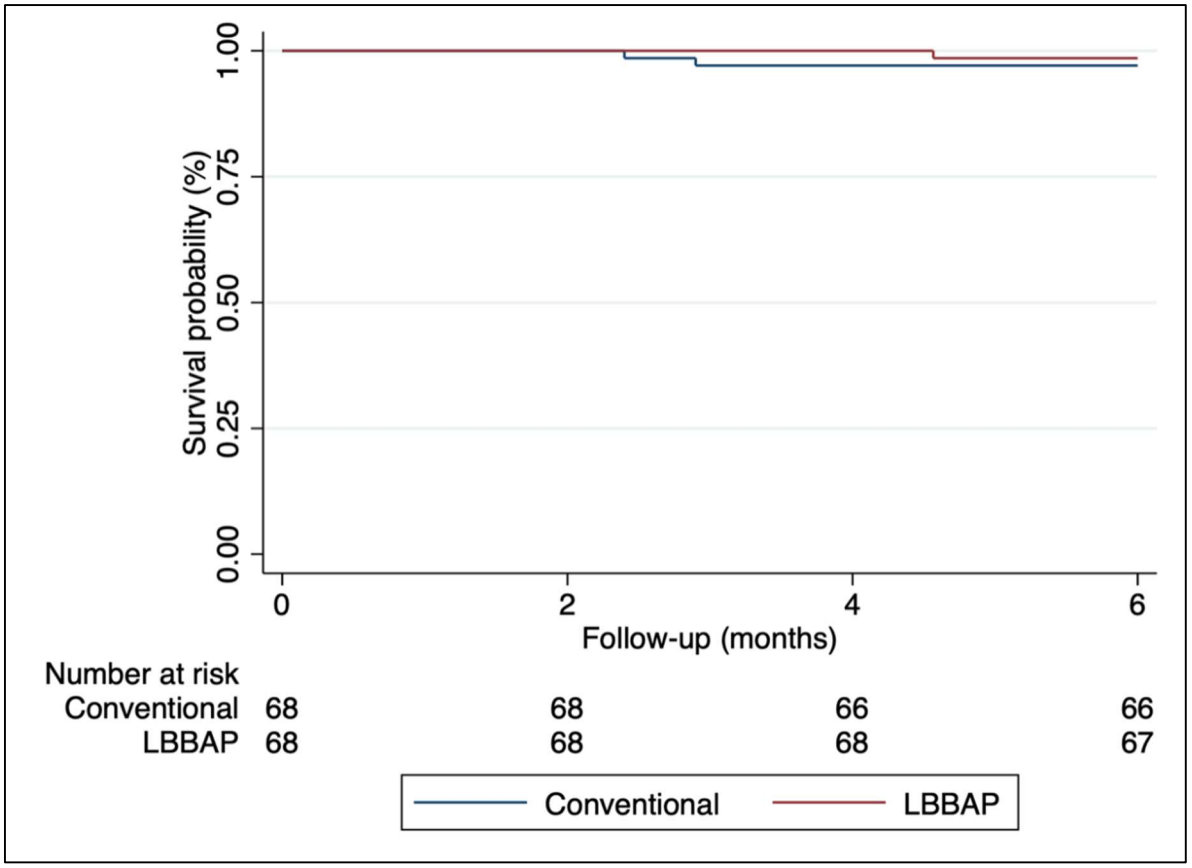

Figure 8. Incidence of all cause death in matched population

LBBAP: Left bundle branch area pacing**.**

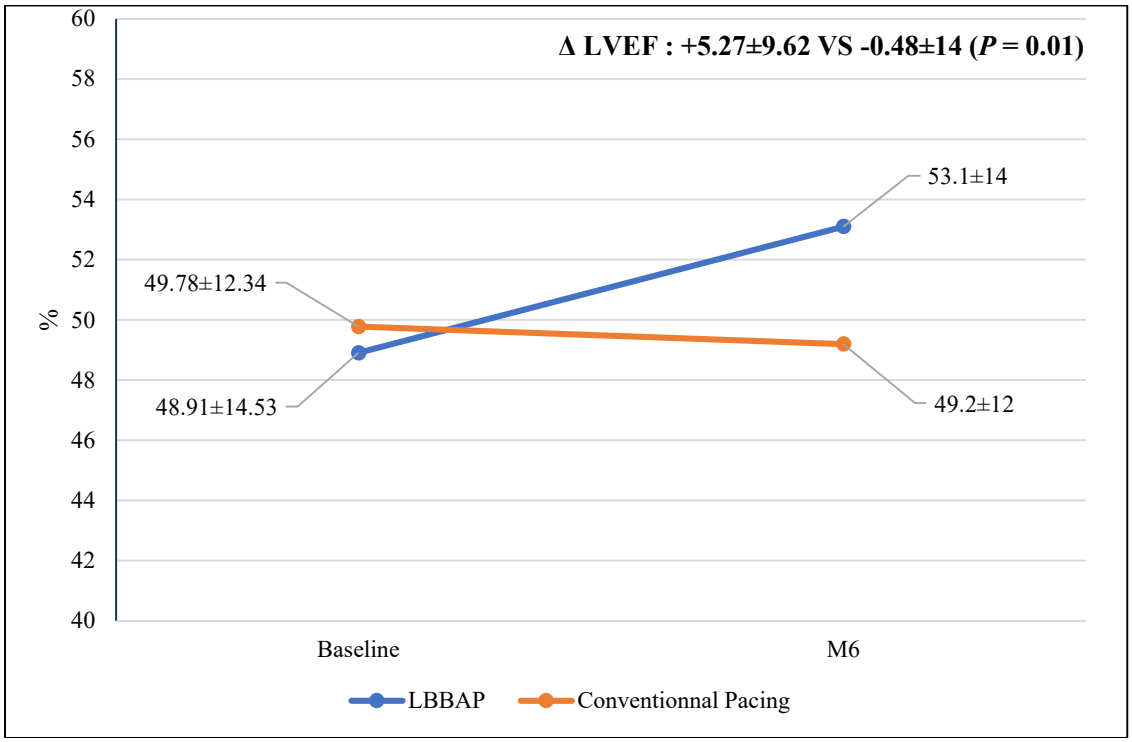

Figure 9. Evolution of left ventricular ejection fraction (Mean±SD) in matched populations.

LVEF: Left ventricular ejection fraction.

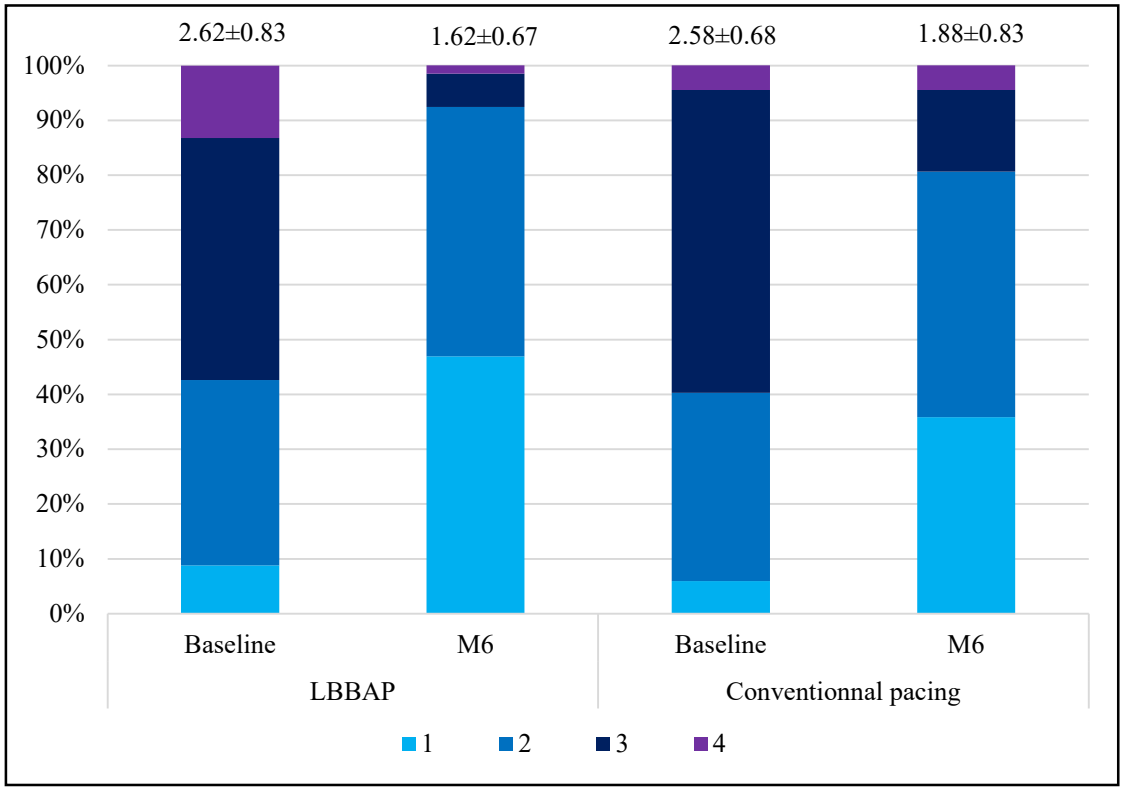

Figure 10. Evolution in NYHA class in matched populations.
Mean ±SD values are displayed on top of each bar.
LBBAP: Left bundle branch area pacing.

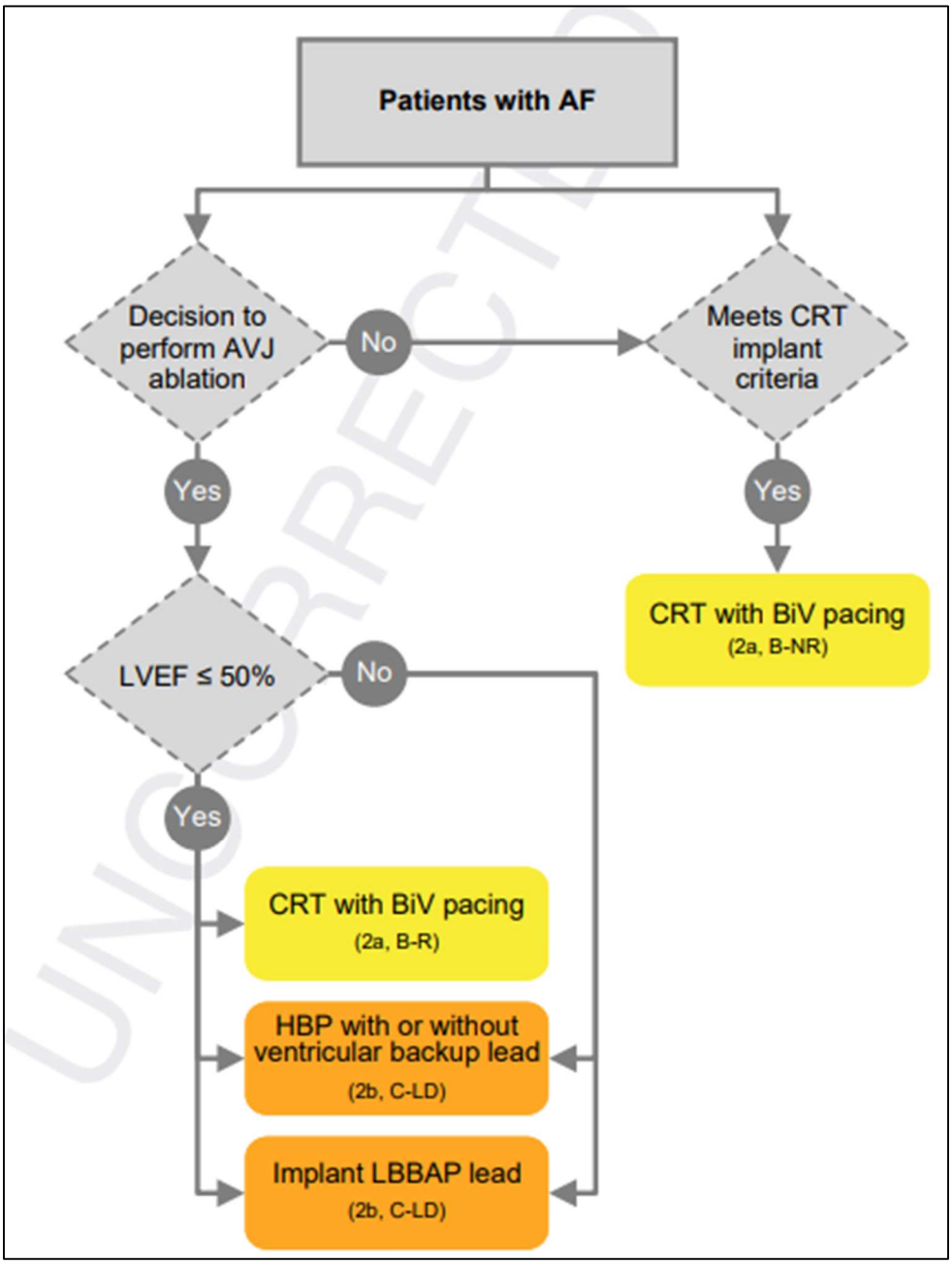

Figure 11. Algorithm for cardiac physiologic pacing in patients with atrial fibrillation, in 2023 HRS guidelines on physiologic pacing[13].

AF: atrial fibrillation; AVJ: atrioventricular junction; BiV: biventricular; CRT: cardiac resynchronization therapy; HBP: His bundle pacing; LBBAP: left bundle branch area pacing; LVEF: left ventricular ejection fraction.

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Vu, le Directeur de Thèse

Vu, le Doyen

De la Faculté de Médecine de Tours, le

JACOBS Mathieu
54 pages – 7 Tableaux – 11 Figures

Résumé :
Introduction : L'ablation du nœud atrio-ventriculaire (NAV) associée à l'implantation d'un pacemaker est un traitement efficace de la fibrillation atriale (FA) symptomatique. La stimulation ventriculaire droite permanente est pourvoyeuse d'asynchronisme cardiaque, pouvant aggraver les symptômes d'insuffisance cardiaques (IC). La stimulation de la zone de la branche gauche est une nouvelle technique de stimulation plus physiologique, moins à risque d'asynchronisme cardiaque.
Objectif : Évaluer la faisabilité, la sécurité et les résultats à 6 mois de l'ablation du NAV associée à une stimulation de la zone de la branche gauche chez des patients atteints de FA symptomatique.
Méthodes : Cette étude rétrospective monocentrique réalisée au CHRU de Tours a inclus consécutivement tous les patients ayant bénéficié d'une procédure d'ablation du NAV associée à une stimulation de la zone de la branche gauche. La procédure d'ablation du NAV, le suivi clinique, électrique et échocardiographique à l'inclusion et à 6 mois ont été étudiés et comparés aux données d'une cohorte appariée de patients ayant reçu une ablation du NAV et stimulation conventionnelle entre mars 2010 et février 2023.
Résultats : 75 procédures d'ablation du NAV et stimulation de la zone de la branche gauche ont été étudiées. La procédure d'ablation du NAV dans ce contexte était faisable, avec un taux de succès de 98,7% à la première ablation, et de 100% après 2 ablations, sans complication et notamment sans déplacement de sonde. Les paramètres électriques du pacemaker à l'implantation étaient bons, et stables à 6 mois, sans élévation de seuil de capture. A 6 mois, 4 (5%) patients ont été hospitalisés pour IC et 1 (1,3%) est décédé. Les patients présentaient une amélioration significative de la classe NYHA, des symptômes de palpitations et de la fraction d'éjection du ventricule gauche (FEVG) ($P \leq 0.0001$ pour tous). Après appariement à une cohorte de patient ayant eu une ablation du NAV et une stimulation conventionnelle, les données d'ablation du NAV et les complications de la stimulation étaient similaires. Les patients avec stimulation de la zone de la branche gauche avaient une amélioration significativement plus importante de la FEVG (+5.27±9.62% versus -0.48±14% ; $P = 0.01$) et avaient un taux d'hospitalisation pour insuffisance cardiaque semblant moins important (HR 0.34, 95% CI: 0.1-1.06; $P = 0.064$).
Conclusion : L'ablation du NAV associée à une stimulation de la zone de la branche gauche en traitement de la FA symptomatique est une procédure faisable, sûre et efficace. Le taux de complication et d'hospitalisation pour insuffisance cardiaque à 6 mois est comparable à celui de la stimulation conventionnelle et l'amélioration de la FEVG est significativement plus importante.

Mots-clés : Fibrillation atriale, ablation du nœud atrio-ventriculaire, stimulation de la zone de la branche gauche

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Date de soutenance 02 octobre 2023