Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

Individualized Left Anterior Oblique Projection

A Highly Reliable Patient-Tailored Fluoroscopy Criterion for Right Ventricular Lead Positioning

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BACKGROUND: Classical fluoroscopic criteria for the documentation of septal right ventricular (RV) lead positioning have poor accuracy. We sought to evaluate the individualized left anterior oblique (LAO) projection as a novel fluoroscopy criterion.

METHODS: Consecutive patients undergoing pacemaker or defibrillator implantation were prospectively included. RV lead positioning was assessed by fluoroscopy using posteroanterior, right anterior oblique 30° to rule out coronary sinus positioning, and LAO 40° in the classical group or individualized LAO in the individualized group. Individualized LAO was defined by the degree of LAO that allowed the perfect superposition of the RV apex (using the tip of the RV lead temporarily placed at the apex) and of the superior vena cava-inferior vena cava axis (materialized by a guidewire), hence providing a true profile view of the interventricular septum. Accuracy of fluoroscopy for RV lead positioning was then assessed by comparison with true RV lead positioning using transthoracic echocardiography.

RESULTS: We included 100 patients, 50 in each study group. Agreement between RV lead septal/free wall positioning in transthoracic echocardiography and fluoroscopy was excellent in the individualized group (k=0.91), whereas it was poor in the classical group (k=0.35). Septal/free wall RV lead positioning was correctly identified in 48/50 (96%) patients in the individualized group versus 38/50 (76%) in the classical group (P=0.004). For septal lead positioning, fluoroscopy had 100% Se and 89.5% Sp in the individualized group versus 91.4% Se and 40% Sp in the classical group. Complications and procedural data were comparable in both groups.

CONCLUSION: Individualized LAO is a quick and highly reliable patient-tailored fluoroscopy projection for RV lead positioning.

VISUAL OVERVIEW: An online visual overview is available for this article.

Key Words: defibrillators ■ echocardiography ■ fluoroscopy ■ heart ventricles ■ ventricular septum

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WHAT IS KNOWN?

- Right ventricle septal lead positioning is standard practice for pacemaker and defibrillator implantation because it carries less risk of tamponade and may reduce pacing-induced cardiomyopathy.
- Current generic fluoroscopy criteria are inaccurate for targeting the right ventricle septum, with most right ventricle free wall leads misclassified as septal.

WHAT THE STUDY ADDS?

- The individualized left anterior oblique projection allows for a better approximation of the true profile view of the interventricular septum.
- Using transthoracic echocardiography as a reference imaging method, the individualized left anterior oblique more accurately identified right ventricle free wall leads than standard fluoroscopy criteria.

Right ventricle (RV) septal lead positioning has now become standard practice for pacemakers or defibrillators implantation because it carries less risk of potential acute cardiac perforation and tamponade and decreases the incidence of delayed pacing-induced cardiomyopathy compared with nonseptal positions.[1] During the implantation procedure, fluoroscopy criteria are routinely used to target the RV septum, with the most useful fluoroscopy projection being the left anterior oblique (LAO) 40°, which is thought to see the heart along its long-axis and thus offers a profile view of the interventricular septum. However, the classical fluoroscopy criteria have proven to be unreliable in several studies,[2–4] with frequent RV leads positioned on the RV free wall despite fluoroscopy indicating a septal position, hence raising major concern about the safety and the efficacy of usual fluoroscopy criteria for RV lead positioning.

To improve the accuracy of fluoroscopy for targeting the RV septum, some authors have proposed alternative fluoroscopy landmarks. The right anterior oblique (RAO) 30° to 40° projection has been suggested to be useful when associated to the LAO 40°,[5,6] as well as the left lateral projection.[7] However, cardiac long-axis orientation present an important interindividual variability[8] and the use of the same generic fluoroscopy projections for every patient remains unsatisfactory.

The purpose of this study was to develop and evaluate the accuracy of a novel patient-tailored fluoroscopy criterion for RV lead positioning: the individualized LAO projection.

METHODS

The data, analytic methods, and study materials will be available to other researchers for purposes of reproducing the results or replicating the procedure.

Consecutive patients undergoing pacemaker or implantable cardiac defibrillator implantation at the Hôpital Pasteur, University Hospital of Nice, were prospectively recruited. All types of devices (VVI, DDD, or with cardiac resynchronization therapy) could be included. Any patient with a history of previously implanted endocardial lead was excluded from this study. All procedures followed our institutional guidelines, and all patients provided their written informed consent. Patients demographics and clinical characteristics were recorded at baseline.

The patients were consecutively included in 1 of the 2 study groups in a 1/1 fashion, using a sequential design: the classical group, using standard fluoroscopy criteria for the prediction of RV lead positioning, and the individualized group, using the individualized LAO projection. Procedural data were recorded for each patient.

Implantation Procedure and RV Lead Positioning

Before the procedure, each patient underwent intravenous antibiotic prophylaxis. Venous access was performed by cephalic vein dissection or by puncture of the axillary vein; in case of failure of these venous accesses, subclavian vein puncture was attempted. The venous access technique has been fully detailed previously.[9] Endocardial screw-in leads were used in all patients for the right atrium and RV positioning. A hand-shaped stylet was inserted in the RV lead to help septal positioning. In case of cardiac resynchronization therapy, a U-shaped or an S-shaped quadripolar lead was positioned in a coronary sinus branch. The pacemaker/defibrillator was placed in a prepectoral pocket, and the skin was closed by overlock suturing with absorbable thread.

Classical Group

For patients in the classical group, RV lead positioning was done immediately after successful venous access. RV lead positioning was performed using classical fluoroscopy criteria that have been extensively described by Mond et al.[10–13] Specifically, the posteroanterior view was used to guide the lead through the tricuspid valve to the RV, and to determine the mid-RV, apical, or RV outflow tract (RVOT) positioning. The RAO 30° view was used to exclude inadvertent positioning of the RV lead in the coronary sinus and great cardiac vein, when suspected (eg, when no ventricular premature depolarization was triggered by the RV lead, and when the RV lead seemed funneled onto the same reproducible upwards pathway despite several mobilization attempts). Finally, the LAO 40° view was performed to determine RV lead septal or free wall positioning: a septal positioning was characterized by a posterior orientation of the tip of the RV lead, whereas a free wall positioning was characterized by a superior or anterior orientation (anterior and lateral free wall), or an inferior orientation (inferior free wall) of the RV lead tip (Figure 1). The target location of the RV lead was septal, however, in case of satisfying pacing threshold, detection, and impedance, the choice was left to the operator to leave the RV lead on a nonseptal suspected positioning.

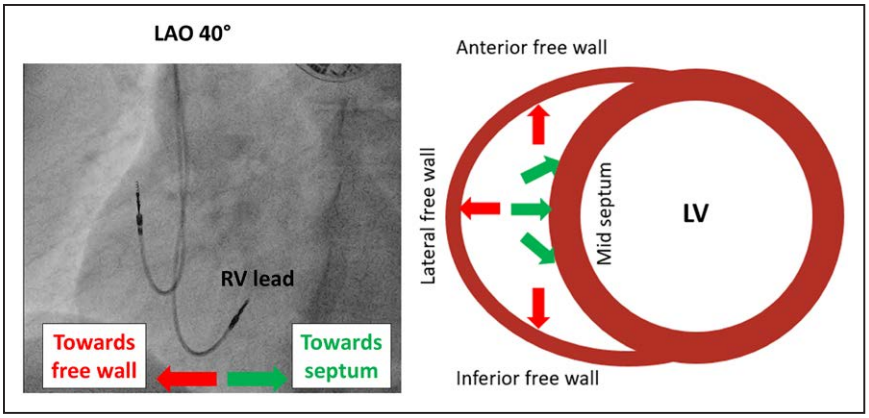

Figure 1. Fluoroscopic criteria of the left anterior oblique (LAO) 40° projection for right ventricle (RV) lead positioning. **Left**, Example of the LAO 40° on a patient with rightwards orientation of the tip of the RV lead, suggesting septal position. **Right**, Schematic representation of the heart as it is deemed to be seen on the ideal LAO projection, with a profile view of the interventricular septum. LV indicates left ventricle.

Individualized Group

For the patients of the individualized group, we sought to determine the degree of LAO that would best offer a true profile view of the interventricular septum, to improve fluoroscopy accuracy in predicting RV lead positioning. First, after successful venous access, a standard 0.35 mm J-shaped guidewire was inserted through the superior vena cava (SVC) down to the inferior vena cava (IVC), using the posteroanterior fluoroscopy projection. The IVC was deemed to be reached when the guidewire proceeded vertically below the heart and the diaphragm silhouette without bending. When the guidewire failed to enter the IVC and bent into the right atrium, it was slightly withdrawn and then gently pushed again until it eventually entered the IVC. This SVC-IVC guidewire provided a posterior fluoroscopy landmark.

Then, the RV lead was inserted through the tricuspid valve into the RV apex using the posteroanterior and the RAO 30° projection. The lead was gently pushed and pulled into the RV until it could not be advanced further and met fluoroscopy criteria for apical positioning. The tip of the RV lead thus provided a fluoroscopy landmark of the RV apex.

Finally, LAO 40° projection was done and the degree of LAO was progressively adjusted by 5° increments until the SVC-IVC guidewire (posterior landmark) perfectly superposed with the tip of the RV lead (apical landmark). The degree of LAO allowing the superposition of both landmarks defined the individualized LAO (Figure 2). The maximum degree of LAO was 70°, to avoid compromising of the sterile field.

After the individualized LAO projection had been determined, the procedure was carried on after standard manners, identically than in the classical group. Importantly, the RV lead was positioned and screwed using classical fluoroscopy criteria, because the accuracy of the individualized LAO projection in predicting RV lead positioning was unknown. The target location of the RV lead was septal—using classical fluoroscopy criteria—however, in case of satisfying pacing threshold, detection, and impedance, the choice was left to the operator to leave the RV lead on a nonseptal suspected positioning. Of note, the information given by the individualized LAO projection were not used by the operator to decide whether the RV lead should be repositioned.

Assessment of RV Lead Positioning by Fluoroscopy

At the end of the procedure, the fluoroscopy views (posteroanterior, RAO 30° when necessary to rule out coronary sinus positioning, and LAO 40° in the classical group or individualized LAO in the individualized group) were performed again to assess the position of the RV lead among 7 possible RV anatomic localizations: septal RVOT, midseptal, septal apical, anterior free wall, lateral free wall, inferior free wall, and apical free wall. Ultimately, all the positions were dichotomized into 2 simple clinically-relevant categories: RV septal or RV free wall.

True RV Lead Positioning by Echocardiography

Within 48 hours after the procedure, true RV lead positioning was assessed by 2-dimensional (2D) transthoracic echocardiography (TTE; ultrasound devices IE33 or CX50, Philips Medical Systems; or Venue 40, GE Healthcare). All standard TTE incidences (parasternal long axis, parasternal short axis, 4-chambers view, 2-chambers view, and subxiphoid view) were performed to determine the anatomic localization of the RV lead tip against the endocardial surface. When the tip of the lead was not clearly seen using these standard incidences, the orientation of the echographic plane was progressively adjusted by following the RV lead body, until the tip was clearly identified against the endocardial surface. The position of the tip of the RV lead was confirmed using at least 2 of the 3 echographic windows (parasternal, apical, and subxiphoid). Loops and screenshots of the RV tip location were recorded and reviewed off-line. The exact localization of the RV lead was assessed (septal RVOT, midseptal, septal apical, anterior free wall, lateral free wall, inferior free wall, or apical free wall), then was also ultimately dichotomized into 2 categories: RV septal or RV free wall.

Patient Follow-Up

After the procedure, pacemaker pocket and suture were examined daily, and lead positioning was checked using chest X-rays at 24 hours. Pacemaker programming was performed after implant and before patient discharge at 48 hours. Each patient underwent a 2-month follow-up consultation with the implanting electrophysiologist, who performed pacemaker pocket and skin examination, ECG recording, and pacemaker programming. Procedural complications were prospectively recorded at up to 2 months after the procedure.

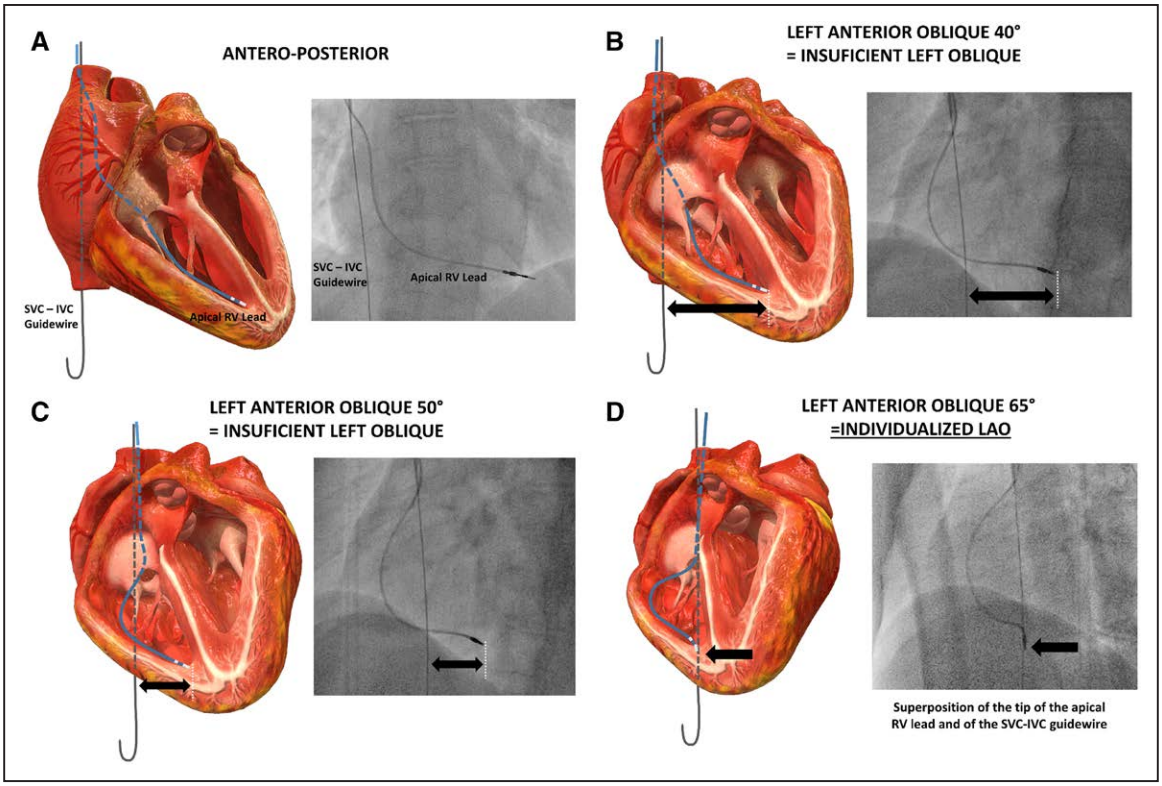

Figure 2. Successive steps for determining the individualized left anterior oblique (LAO) projection.
A 3-dimensional heart model is shown for each corresponding fluoroscopy projection. First, the superior vena cava (SVC)-inferior vena cava (IVC) guidewire is positioned, and the right ventricle (RV) lead is placed (unscrewed) at the RV apex (**A**). Then, LAO 40° is performed (**B**), and the degree of LAO is progressively adjusted until there is a perfect superposition of the SVC-IVC guidewire and of the tip of the apical RV lead (**C** and **D**). In this case, the individualized LAO was LAO 65° (**D**).

Statistical Analysis

Numeric variables were presented as mean and SD, and categorical variables as percentages. Numeric variables were compared using the Student *t* test. Differences in categorical variables were assessed using the χ^2 test. Sensitivity and specificity of the fluoroscopy to predict RV lead positioning in both study groups were assessed compared with the TTE reference. Agreement between fluoroscopy and TTE was calculated using the κ coefficient. Statistical significance was defined by a *P* value of <0.05.

RESULTS

We included 100 patients, 50 in each study group. The first 50 patients were included in the classical group, and the last 50 patients were included in the individualized group. Patients demographics and procedural data are summarized in the Table.

Overall, agreement for RV lead exact anatomic positioning between classical fluoroscopy and TTE was moderate (k=0.55), whereas it was excellent between fluoroscopy with individualized LAO and TTE (k=0.93). When the RV lead positioning was dichotomized into RV septal or RV free wall, agreement between TTE and classical fluoroscopy was only poor (k=0.35) but was again excellent with fluoroscopy with individualized LAO (k=0.91). Septal or free wall RV lead positioning was correctly identified in 48/50 (96%) patients in the individualized group versus 38/50 (76%) in the classical group (*P*=0.004). Concordance for RV lead positioning between TTE and classical fluoroscopy or fluoroscopy with individualized LAO are detailed in Figures 3 and 4, respectively.

In both study groups, sensitivity of fluoroscopy was high to predict RV lead septal positioning because 32/35 patients demonstrating a septal RV lead in TTE were also classified as septal with classical fluoroscopy (sensitivity=91.4%), and 31/31 patients with fluoroscopy with individualized LAO (sensitivity=100%; *P*=0.1 for comparison between both groups). However, classical fluoroscopy had a very low specificity in predicting septal positioning, with only 6/15 patients having an RV free wall lead in TTE appropriately classified by fluoroscopy (specificity 40%); whereas fluoroscopy with individualized LAO was able to correctly identify 17/19 patients having an RV free wall lead on TTE (specificity=89.5%; *P*=0.002 for comparison between both groups). Figures 5 and 6 show the comparison between classical fluoroscopy criteria and individualized LAO in several patients, with TTE confirming RV lead positioning.

The degree of the individualized LAO was ≥60° in the majority of the patients (29/50; 58%), between 50° and 60° in 15/50 (30%), and between 40° and 50° in only 6/50 patients (12%). No patient had a degree of individualized LAO <40° (Figure 7).

Table. Patients Demographics and Procedural Data

	Classical LAO 40° Group (n=50)	Individualized LAO Group (n=50)	*P* Value
Patients demographics			
Age, y	78.4±11.1	78.7±12.0	0.90
Female gender	17/50 (34%)	27/50 (54%)	0.04*
Hypertension	29/50 (58%)	27/50 (54%)	0.69
Diabetes mellitus	13/50 (26%)	11/50 (22%)	0.64
Dyslipidemia	13/50 (26%)	19/50 (38%)	0.20
Anticoagulant treatment	25/50 (50%)	25/50 (50%)	1
Cardiopathy (any)	18/50 (36%)	24/50 (48%)	0.22
Coronaropathy	14/50 (28%)	11/50 (22%)	0.49
Valvulopathy	10/50 (20%)	11/50 (22%)	0.81
Impaired LVEF (<50%)	3/50 (6%)	10/50 (20%)	0.04*
Impaired right ventricle function	4/50 (8%)	10/50 (20%)	0.08
Procedural data			
VVI or DDD pacemaker	46/50 (92%)	46/50 (92%)	1
VVI or DDD ICD	3/50 (6%)	2/50 (4%)	0.65
CRT device	1/50 (2%)	2/50 (4%)	0.56
Fluoroscopy duration, min	3.7±2.5	4.7±4.8	0.21
X-Ray exposure, mGy cm^2	1730.8±1373.2	2361.1±2091.8	0.09
Septal RV lead on TTE	35/50 (70%)	31/50 (62%)	0.40
Total complications	3/50 (6%)	4/50 (8%)	0.70
Pericardial effusion	2/50 (4%)	0	0.15
Lead dislodgement	0	0	1
Pocket hematoma	0	2/50 (4%)	0.15
Pneumothorax	0	1/50 (2%)	0.31
Device infection	1/50 (2%)	0	0.31
Subclavian thrombosis	0	1/50 (2%)	0.31

CRT indicates cardiac resynchronization therapy; ICD, implantable cardiac defibrillator; LAO, left anterior oblique; LVEF, left ventricular ejection fraction; RV, right ventricle; and TTE, transthoracic echocardiography.

*P<0.05.

The individualized LAO projection was easy and quick to determine, with feasibility of 100% in the 50 patients included in the individualized group. For most patients, the SVC guidewire very easily proceeded to the IVC to provide the SVC-IVC landmark. In some patients, the guidewire initially bent in the right atrium without entering the IVC, and several attempts were necessary to eventually reach the IVC. All the maneuvers necessary to determine the degree of the individualized LAO (SVC-IVC guidewire positioning, apical lead positioning, then LAO adjustment) took between 2 to 5 minutes to be completed.

Fluoroscopy duration was not significantly different in both groups (P=0.21; Table for details), but there was a trend toward more X-ray exposure in the individualized LAO group (2361.1±2091.8 versus 1730.8±1373.2 mGy cm^2; P=0.09).

The complication rate was comparable in both groups with 3/50 (6%) complications in the classical group versus 4/50 (8%) in the individualized group (P=0.7). One patient in the classical group required a reintervention for device infection at 2 months. Two pericardial effusions occurred in the classical group in anticoagulated patients demonstrating an RV lead on anterior free wall in TTE; one was treated medically, whereas the other underwent a subxiphoid pericardial puncture without RV lead repositioning. For these 2 patients, the fluoroscopy was inaccurate and predicted a midseptal RV lead positioning at the time of the procedure.

DISCUSSION

Main Results

This study is this first to use a patient-tailored fluoroscopy projection for assessing RV lead positioning. Our results show that the use of the individualized LAO projection instead of the generic LAO 40° projection allowed for much more accuracy in determining RV lead septal/free wall positioning, with 96% of the patients correctly classified in the individualized group versus only 76% in the classical fluoroscopy group. More specifically, the individualized LAO projection strongly improved the specificity of the fluoroscopy for predicting septal positioning (89.5% versus 40% for LAO 40°) without impairing sensitivity (100% versus 91.4% for LAO 40°), thus allowing for a much better identification of free wall RV leads, which are most of the time misclassified as septal by classical fluoroscopy. Moreover, the individualized LAO projection was easy and straightforward to determine, with feasibility of 100% and a short required time.

Flaws of the Usual Per-Procedural Tools for Targeting the RV Septum

ECG and fluoroscopy are the 2 main tools that the electrophysiologist can use at the time of the implant procedure to target the interventricular septum. ECG criteria have been studied previously and led to highly variable conclusions,[2–4,10,14,15] rendering its use subject to caution for RV lead positioning. However, the inaccuracy of the classical fluoroscopy criteria has also been previously shown in several studies, using either TTE[2] or computed tomography scan[3,4] as a reference. They reported at best moderate agreement between fluoroscopy and the reference imaging, with frequent free wall RV lead positioning despite a posterior (rightwards) orientation of the tip of the RV lead on LAO 40° projection.

The poor correlation between the orientation of the RV tip in LAO 40° and true RV lead positioning could be explained by the fact that this projection has been

		Classical Fluoroscopy criteria										
		All septal positions	Septal RVOT	Mid septal	Septal apical	All free wall positions	RVOT free wall	Anterior free wall	Lateral free wall	Inferior free wall	Apical free wall	Total
Echocardiography	All septal positions	32				3						35
	Septal RVOT		-	-	-		-	-	-	-	-	0
	Mid septal		-	20	-		-	3	-	-	-	23
	Septal apical		-	2	10		-	-	-	-	-	12
	All free wall positions	9				6						15
	RVOT free wall		-	-	-		-	-	-	-	-	0
	Anterior free wall		-	7	1		-	5	-	-	-	13
	Lateral free wall		-	-	-		-	-	-	-	-	0
	Inferior free wall		-	1	-		-	-	-	1	-	2
	Apical free wall		-	-	-		-	-	-	-	-	0
	Total	41	0	30	11	9	0	8	0	1	0	50

Figure 3. Comparison between lead position as assessed by classical fluoroscopy and true anatomic position as assessed by transthoracic echocardiography.
Concordances between the 2 imaging modalities are highlighted in green, discordances are highlighted in red. RVOT indicates right ventricular outflow tract.

arbitrarily chosen and only grossly approximates a view along the long-axis of the heart, providing most of the time a skewed profile view of the septum. A magnetic resonance imaging study[8] showed that cardiac long-axis orientation in the transversal plane presented an important interindividual variability, supporting the finding that the same generic LAO 40° is inaccurate in numerous patients. Actually, the fact that most patients having a free wall RV lead in the classical group of our study presented a rightwards orientation of the RV tip in LAO 40°—thus incorrectly suggesting septal positioning—indicates that the correct degree of LAO in these patients is higher than 40°. This was indeed confirmed with the patients of the individualized group, demonstrating that the correct degree of LAO was rarely around 40°, but most of the time around 60° (34/50 patients had an individualized LAO angle ≥50° and <70°; 68%). Accordingly, if the operator wants to use a generic LAO projection for RV lead positioning, we would advise LAO 60° instead of LAO 40°, because it would approximate the true LAO in around 2/3 of the patients.

Some alternative fluoroscopy landmarks have been proposed to improve accuracy. The RAO 30° to 40° projection has been suggested to be useful when associated to the LAO 40°, with a high proportion of patients having a truly septal RV lead position when the tip of the lead was directed rightwards in LAO 40° and when it was placed in the middle or the inferior quadrants of the RV in RAO 30° to 40°.[5,6] However, the inferior border of the heart is often difficult to see in RAO 30° to 40° because of the superimposition with the diaphragm silhouette, and the segmentation of the heart in quadrants can be arbitrary. The use of the left lateral projection has also been reported to be valuable[7]; but this projection is usually difficult to per-

		Individualized LAO										
		All septal positions	Septal RVOT	Mid septal	Septal apical	All free wall positions	RVOT free wall	Anterior free wall	Lateral free wall	Inferior free wall	Apical free wall	Total
Echocardiography	All septal positions	31				-						31
	Septal RVOT		1	-	-		-	-	-	-	-	1
	Mid septal			28	-		-	-	-	-	-	28
	Septal apical		-	-	2		-	-	-	-	-	2
	All free wall positions	2				17						19
	RVOT free wall		-	-	-		1	-	-	-	-	1
	Anterior free wall		-	1	-		-	12	-	-	-	13
	Lateral free wall		-	-	-		-	-	1	-	-	1
	Inferior free wall		-	-	-		-	-	-	-	-	0
	Apical free wall		-	-	1		-	-	-	-	3	4
	Total	33	1	29	3	17	1	12	1	0	3	50

Figure 4. Comparison between lead position as assessed by fluoroscopy with individualized left anterior oblique (LAO) and true anatomic position as assessed by transthoracic echocardiography.
Concordances between the 2 imaging modalities are highlighted in green, discordances are highlighted in red. RVOT indicates right ventricular outflow tract.

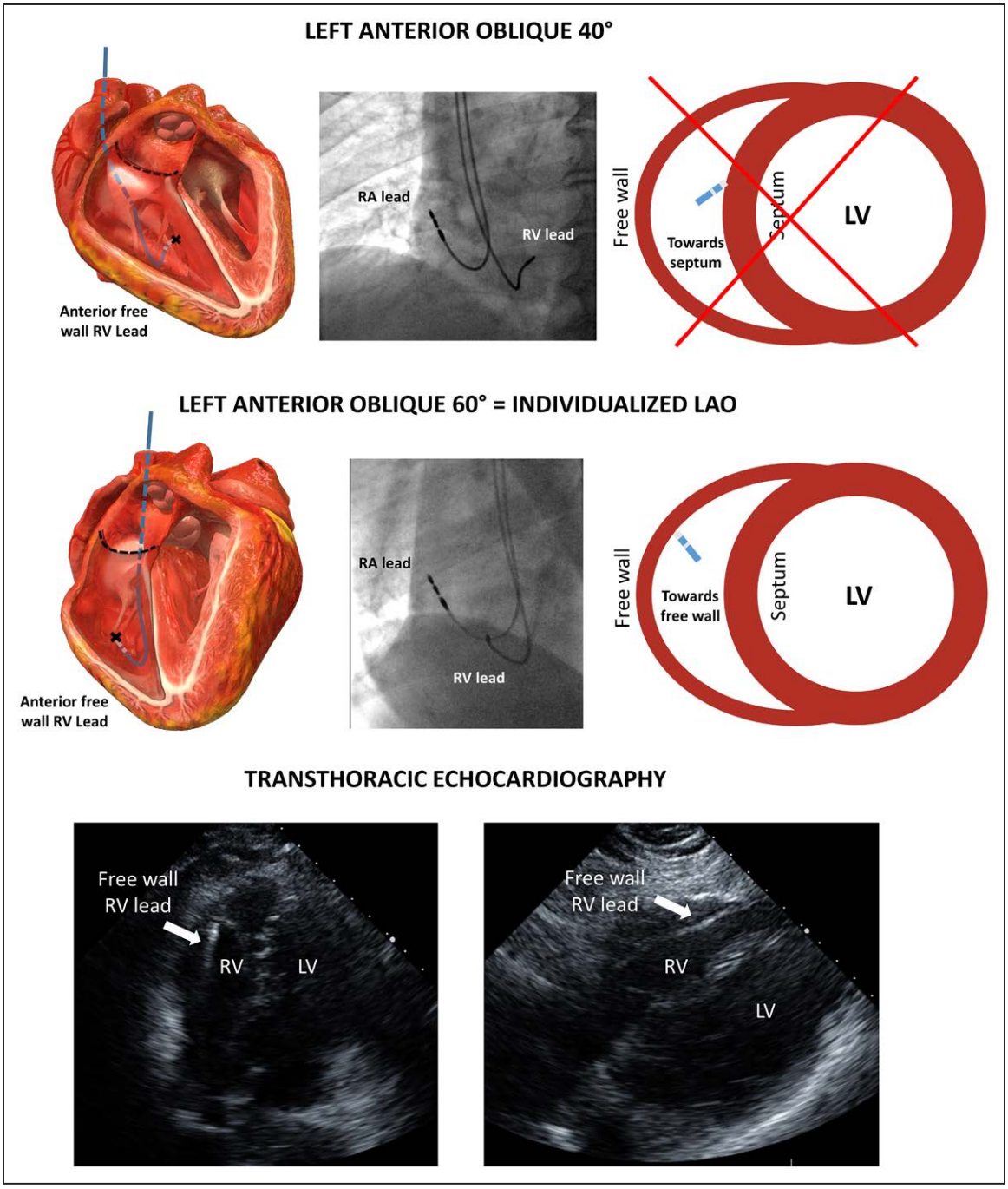

Figure 5. Example of a patient having a left anterior oblique (LAO) 40° projection predicting a septal positioning of the right ventricle (RV) lead (rightward orientation of the RV lead tip), but for which the realization of the individualized LAO suggested an RV free wall positioning (leftward orientation of the RV lead tip).

Transthoracic echocardiography confirmed individualized LAO finding, with the RV lead on the free wall. LV indicates left ventricle; and RA, right atrium.

form during the implant procedure without compromising the sterile surgical field. Nevertheless, these additional fluoroscopy projections remain somewhat unsatisfactory in the fact that they are unadjusted to the patient's anatomy and might lead to flawed conclusions.

Some implantation techniques have been proposed for helping RV lead septal positioning.[12] Most commonly, the RV lead is loaded with a curved hand prepared stylet and is pushed through to tricuspid valve. Then, the body of the lead is arched into the RVOT and can be prolapsed into the pulmonary artery. Once in the pulmonary artery, the lead is retracted into the RVOT or mid-RV, and contact is made with the septal wall by counterclockwise rotation. Septal positioning can be facilitated at this point by the use of a double-curved stylet with a distal posterior angulation.[16]

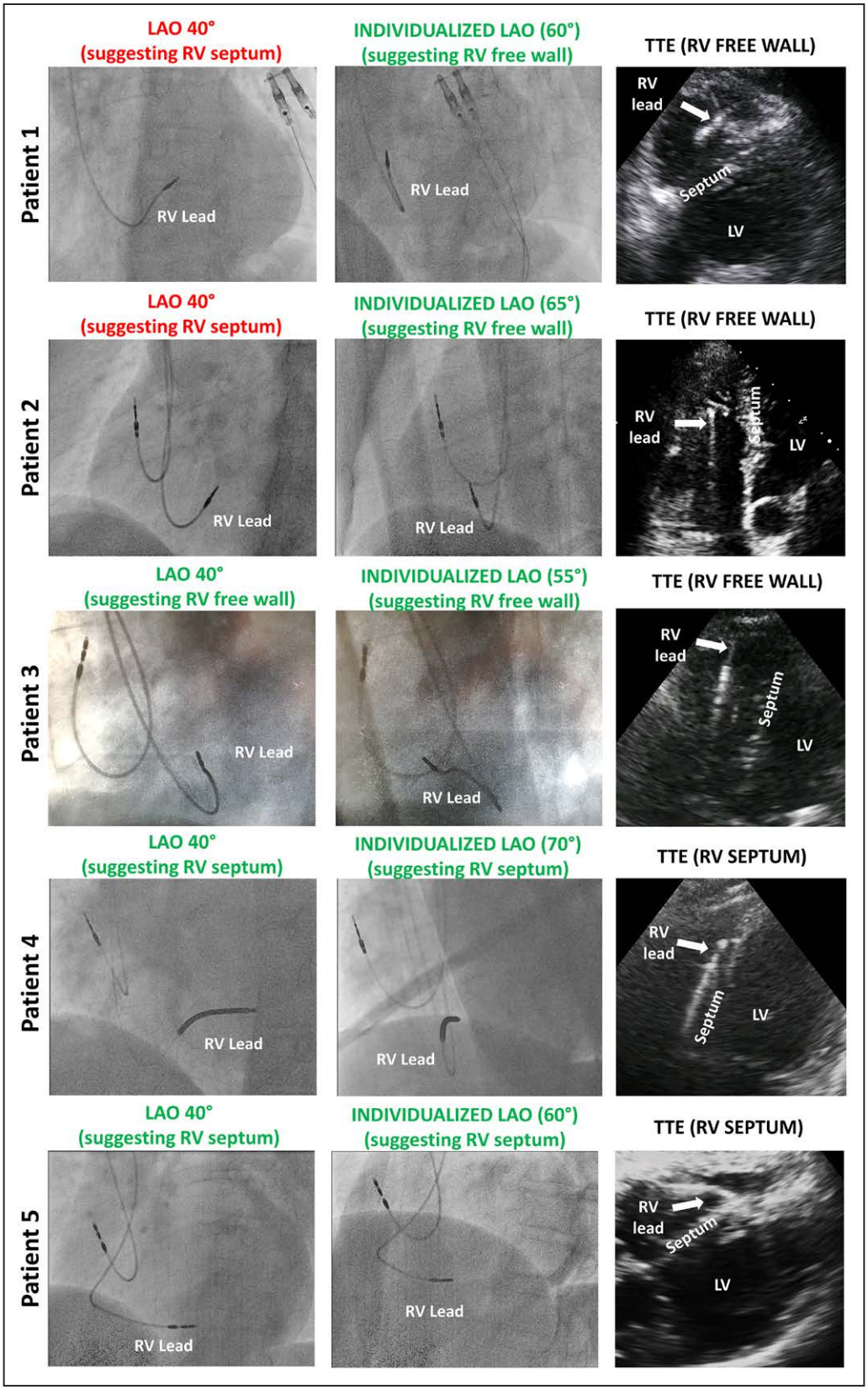

Figure 6. Several examples of patients of the individualized left anterior oblique (LAO) group, with comparison of LAO 40° and individualized LAO, and corresponding transthoracic echocardiography (TTE).
Patient 1 and patient 2 were incorrectly classified by LAO 40° but correctly by individualized LAO. For the 3 other patients, both fluoroscopy criteria were right. LV indicates left ventricle; and RV, right ventricle.

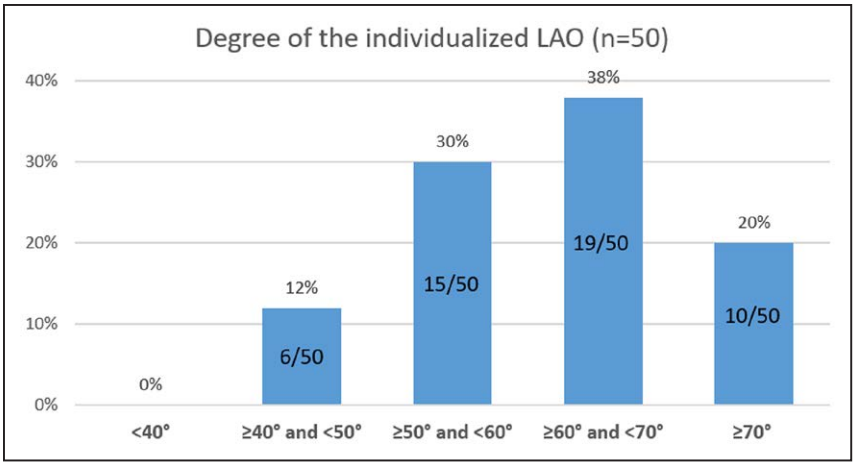

Figure 7. Distribution of individualized left anterior oblique (LAO) projections.

Implications of Using the Individualized LAO Projection

The individualized LAO projection is a patient-tailored fluoroscopy projection that provides, by aligning a posterior and an apical landmark, a better approximation of the true profile view of the interventricular septum. Therefore, during implant procedures, the operator could rely on the orientation of the tip of the RV lead with a much higher confidence level than using standard LAO 40°. The use of this individualized LAO projection might help the cardiologists to ascertain RV lead septal positioning, which could have important clinical implications, and could also be of interest for research purposes.

On a clinical standpoint, the ability to accurately target the interventricular septum can have major consequences. Placing an RV lead outside the septum carries a potential risk of myocardial perforation and of pericardial effusion and tamponade,[17] which is virtually inexistent in case of septal pacing. Furthermore, pacing the RV outside the septum results in a more dyssynchronous contraction and in more midterm and long-term LVEF decrease than septal pacing and could lead to pacing-induced cardiomyopathy, as shown in a meta-analysis of 14 randomized controlled trials.[1]

Also, the use of a reliable fluoroscopy criterion for septal positioning might help in research to avoid allocation bias, which could potentially be an explanation for the variable results of the randomized controlled trials—which consistently used fluoroscopic landmarks for validation of RV lead positioning—comparing septal and apical pacing, and for the lack of significant differences in terms of New York Heart Association heart failure class in most randomized controlled trials examining this end point.[18–22]

Limitations

Our study has several limitations. First, the sequential design may reduce the generalization of the study findings and led to some imbalances between the 2 study arms (female gender and impaired LVEF more frequent in the individualized LAO group). Also, our study did not assess the accuracy of the 2D TTE in localizing pacing leads against other imaging techniques, such as 3D TTE or computed tomography scan. However, we think that 2D TTE can be used as a reference anatomic method in the identification of pacing leads in the RV, because 2D TTE has a higher spatial and temporal resolution compared with 3D TTE, and it allowed clear visualization of the insertion site of the RV leads in all patients of our study. Additionally, computed tomography scan was not performed because of concerns about the radiation exposure and potential anaphylaxis that was not clinically indicated.

The results of our study might be biased by the lack of blinding among the 2 methods used to define pacing leads position because 1 investigator (Dr Squara) was involved in implant procedures and was also involved in data analyzing. However, all echocardiograms and fluoroscopy images were analyzed separately and in random order.

Hand-shaped stylets were used in this study. Preformed stylets (like the Mond stylet) may further help septal positioning; however, it would likely not change sensitivity and specificity of fluoroscopy criteria for septal positioning.

The position of the lead temporarily positioned at the RV apex in the individualized group was assessed using fluoroscopy. It is possible that some leads were not at the true RV apex but rather in the apical region. However, the apex has funnel-like anatomy and a lead positioned in the apical region should still give a good approximation of the most distal part of the septum and could, therefore, be used as an adequate fluoroscopic landmark for determining individualized LAO.

Finally, this study assessed the accuracy of individualized LAO for predicting RV lead positioning, but during the implant procedure, the RV lead was positioned and screwed using classical fluoroscopy criteria, because the accuracy of the individualized LAO projection had nev-

er been evaluated previously. Prospective randomized studies are warranted to confirm the value of this new fluoroscopy projection.

Conclusions

The individualized LAO projection is a quick and highly reliable patient-tailored fluoroscopy projection that can be used during implant procedures for helping RV lead septal positioning. In cases where a generic LAO projection is preferred by the operator, the use of LAO 60° would approximate the optimal LAO in around two-thirds of the patients and should replace LAO 40°.

ARTICLE INFORMATION

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Disclosures

None.

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