# Combined complex electrophysiological interventions due to improved standardization and efficiency: proof of concept.

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The field of cardiac electrophysiology (EP) is evolving rapidly. Over the years, with the evolution of ablation technologies, including the development of irrigated ablation catheters with contact force sensing, steerable sheaths, 3-dimensional mapping systems, multipolar mapping catheters and pre- and peri-procedural imaging, the treatment of complex arrhythmias with catheter ablation has expanded significantly. Implementation of lean management strategies for complex EP procedures, with standardized, simplified, shorter and more predictable workflows, has the potential to significantly enhance procedural efficiency.(1-6)

Multiple arrhythmias may co-exist in the same patient. The co-existence of arrhythmias may present unique management problems. For instance atrial arrhythmias are a common causes of inappropriate ICD therapy.(7) These inappropriate shocks are potentially responsible for an increased mortality.(8, 9) Eliminating atrial fibrillation and atrial flutter, could reduce appropriate and inappropriate therapy and potentially reduce mortality. Multiple co-existing arrhythmias could be treated during the same procedure, using the same EP material and with standardized workflows. Combinations of VT ablation with PVI or CTI could have potential advantages, including a reduction in the number of procedures, a reduction in complication rates, and more effective utilization of healthcare resources.

The aim of the present study was to analyze the feasibility, safety and effectiveness of combined complex endocardial only VT ablation procedures with atrial ablation procedures. VT ablation was performed using an image-integration guided and substrate-based ablation in sinus rhythm

(50W; QDOT catheter). The MUSIC/inHEART technology, was used for image integration as described previously.(2)

Nine patients were included between April 2020 and April 2022 (8 [89%] male; 8 [89%] structural heart disease; age 66±7 years, Table 1). Four (44%) underwent AF ablation and CTI-dependent flutter ablation in addition to VT ablation, 3 (33%) underwent AF ablation in combination with VT ablation and 2 (22%) had CTI-only ablation in addition to VT ablation. All patients had a history of AF (7 [77%] paroxysmal AF; 2 [22%] persistent AF). One third of the patients (n=3) had inappropriate defibrillator shocks for rapidly conducted atrial fibrillation. All patients who underwent VT ablation had appropriate therapy (sustained VT with V1- in n=3 and V1+ in n=3) and two patients came with electrical storm. Three patients had inappropriate shocks. Among the cohort of AF ablation patients three individuals had symptomatic atrial fibrillation, three patients were ablated prior to CRT upgrade to increase chances of synchronization obtaining biventricular pacing of >98%. Two patients had severe mitral regurgitation and AF ablation was performed prior to Mitraclip. One patient had a tachycardiomyopathy with a LVEF of 35% due to fast persistent atrial fibrillation.

The predefined procedure endpoints for AF (pulmonary vein isolation) and VT ablation (CT channel elimination and non-inducibility of any VT) were reached in all 9 patients (Examples in Figure 1). There were no acute procedure-related complications. Skin-to-skin duration was 162.9±40.7 min. The incremental procedure time to complete the atrial ablation was 23±4 min. Of note, atrial FAM mapping is routinely performed as part of the image integration protocol

prior to VT ablation. Ablation time (first to last ablation application) for PVI was comparable to the previously reported POWER-PLUS study.(10) The remaining time of the skin-to-skin duration was counted as the procedural time for VT ablation. There were no significant differences in procedure time for the VT ablation procedure in comparison to the previously reported MUSIC-VT study.(2) The RF-time for VT ablation was also not significantly different in our cohort, although we observed a trend towards lower ablation time.

After a mean follow-up of 8.1±8.3 months, 6 patients were free of any atrial or ventricular arrhythmia. One patient underwent cardioversion for atypical atrial flutter. Two patients had recurrence of sustained VT, one of which was terminated by ATP and the other one by administration of Amiodarone. One patient had recurrent PVCs. Recurrence rates did not differ significantly from the matched patients in the POWERPLUS and MUSIC VT study, respectively (Table 5). No procedure-related complications were identified during follow-up.

The main findings of our study are as follows: 1. In experienced centers and well selected patients, a combined VT ablation and PVI is feasible with an average combined procedure time of less than three hours; 2. With streamlined and efficient workflows, the increase in procedure time associated with atrial ablation procedures, including PVI, is less than 30 minutes; 3. Despite the reduced cardiac reserve in patients undergoing VT ablation, combined VT and atrial ablation procedures do not appear to increase complication rates or compromise efficacy.

We demonstrate that a single ablation catheter can be used for ablation of not only multiple atrial arrhythmias but also ventricular tachycardia during the same procedure. A very high power short duration AF ablation has a low risk for stroke and silent emboli and can be performed in a safe and efficient workflow as demonstrated in the FAST AND FURIOUS PVI Study.(6, 11, 12) Additionally, a substrate-based VT ablation approach in sinus rhythm can be performed in around two hours with a favourable safety profile.(2, 13) Due to increased standardization (CLOSE-PVI and substrate-based CT channel ablation in sinus rhythm), new ablation power strategies (50-90W) and additional tools as preprocedural imaging, and multipolar mapping catheters for efficient high-density mapping and specific pacing manoeuvres, both AF and VT procedures became shorter and more predictable.(6, 12, 14, 15) However, our findings need to be validated in larger studies, with potential additional data on resource utilization and patient satisfaction. Finally, it is important to note that while the use of standardized AF ablation strategies is widespread, there remains heterogeneity in terms of VT ablation strategies. For instance, the use of inHeart image integration-based VT ablation is currently limited to specific centres and the data supporting the approach is limited to single centre studies.

## Conflicts of interest

I have read the journal's policy and the authors of this manuscript have the following competing interests: BB received proctoring, lecture, travelling and consulting fees from Biosense Webster. RK and SNM received research grants and consulting fees from Biosense Webster. HP has received honoraria/consultation fees from Abbott, Biosense Webster, Boston Scientific, Medtronic. None of the other authors declared a conflict of interest.

## Financial disclosure

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## Data availability statement

All relevant data appear in the manuscript. Other data are available upon reasonable request at Benjamin.berte@cardiopuls.ch

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## Table 1.

| | Combined EP | MUSIC VT | POWERPLUS | p value |
|---|---|---|---|---|
| **Clinical characteristics** | | | | |
| **total number of patients** | 9 | 49 | 90 | |
| Age, mean (SD) years | 66 (7.5) | 63 (15) | 64.2 (8.9) | 0.708 |
| Male, n (%) | 8 (89) | 44 (90) | 61 (67.8) | 0.009 |
| Paroxysmal AF, n (%) | 7 (77.8) | NK | 64 (71.1) | 0.672 |
| Persistent AF (>7d) n,(%) | 2 (22.2) | NK | 26 (28.9) | 0.672 |
| BMI, mean (SD) $kg/m^2$ | 26.7 (5) | 26.6 (3.7) | 26.6 (3.1) | 0.997 |
| Hypertension, n (%) | 3 (33.3) | 29 (59) | 41 (45.6) | 0.188 |
| Structural heart disease, n (%) | 8 (89) | 43 (88) | 16 (17.8) | < 0.00001 |
| Diabetes, n (%) | 4 (44.4) | 4 (8) | 8 (8.9) | < 0.00001 |
| $CHA_2DS_2VAS_C$, median (IQR) | 4.0 (4) | 4.1 (1.4) | 2.0 (3) | < 0.00001 |
| LAVI ml/m2, mean (SD) mm | 46.9 (17.8) | 19 (39) | 38.9 (5.1) | < 0.00001 |
| Inappropriate shocks, n (%) | 3 (33.3) | NK | | - |
| Appropriate shocks or ATP, n (%) | 9 (100) | 49 (100) | | - |
| **Procedural characteristics** | | | | |
| Net procedure time for PVI, median (IQR) min | 27 (8) | NA | 70 (20) | < 0.00001 |
| Procedure time VT, mean (SD) min | 140.2 (41.5) | 172 (48) | NA | 0.062 |
| Steam pop during case | 0 | 1 (4%) | 1 (1.1) | - |
| Char at inspection | 0 | 0 | 0 | - |
| Ablation time mean (SD) - 1st to last tag, mins | 22.8 (4) | 80 (37) | 32 (12) | <0.00001 |
| RF delivery time LA required, mean (SD) mins | 6.4 (1.5) | NA | 4.5 (1.2) | 0.005 |
| RF-time VT, mean (SD) min | 15.4 (9.1) | 31 (17) | NA | <0.001 |
| Overall Procedure time, mean (SD) min | 163 (22.8) | 172 (48) | 70 (20) | < 0.00001 |
| **Safety and Effectiveness** | | | | |
| Major complications, n (%) | 0 | 1 (2) | 0 | - |
| Minor complications, n (%) | 0 | 1 (2) | 0 | - |
| Recurrence, n (%) | 2 (22.2) | 13 (27) | 15 (16.6) | 0.380 |
| Mortality, n (%) | 0 | 2 (4) | 0 | - |

| | | | | |
|---|---|---|---|---|
| Appropriate therapy (ATP/Schock) | 1 (11.1) | NK | NA | - |

**Abbreviations:**
SD, standard deviation, n, number; d, days; AF, atrial fibrillation; LAVI, left atrial volume; ATP, antitachycardia pacing; VT, ventricular tachycardia; min, minutes; IQR, interquartile range; NA, not applicable; NK, not known; mm, millimeters;

## Figure 1. Examples of combined complex EP procedures.

Figure legend: Six examples of combined atrial and ventricular ablation procedures using a 3D mapping system (CARTO, Biosense Webster), a substrate model of the patients' ventricular scar (inHEART), a dedicated mapping catheter (PentaRay or OctaRay, both Biosense Webster) and an ablation catheter (QDOT, Biosense Webster and or Farapulse, Boston Scientific).

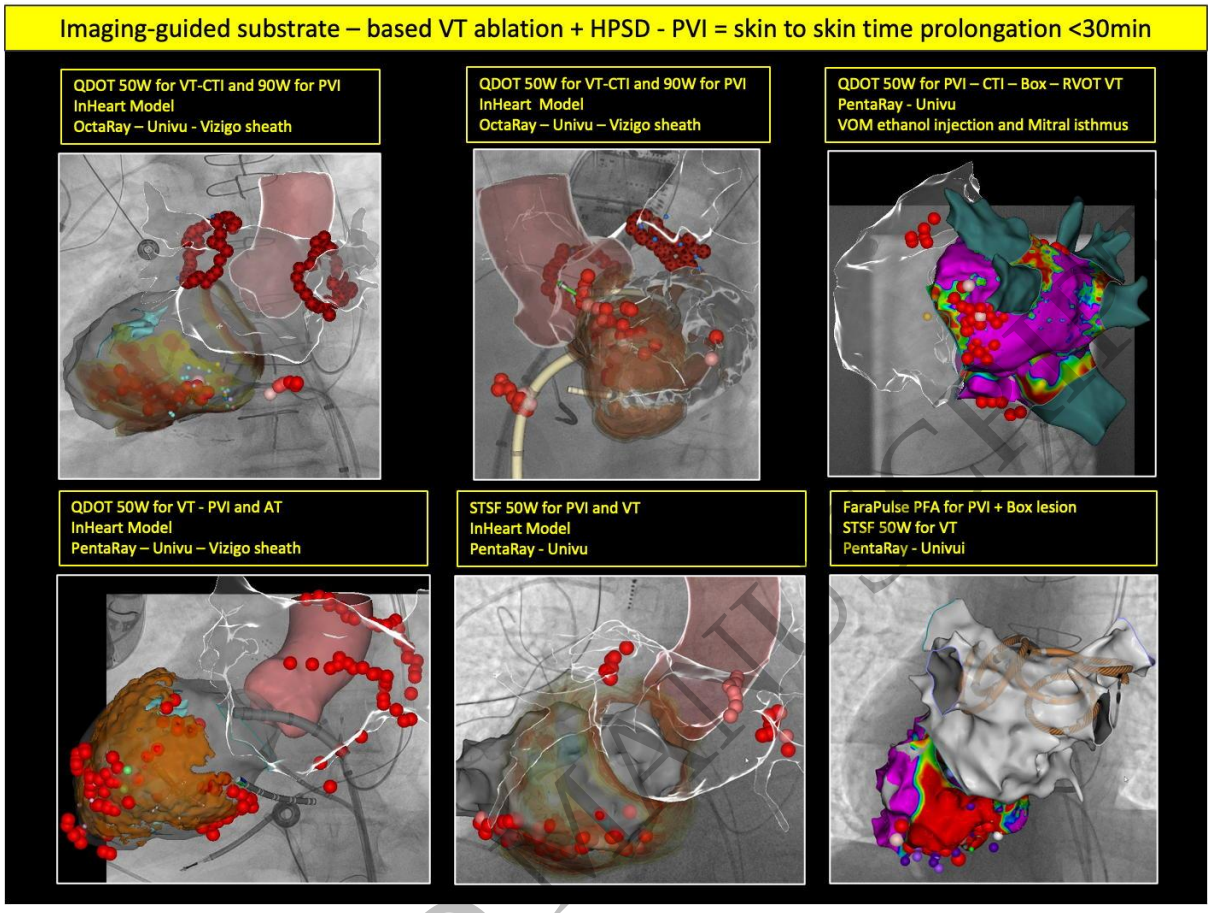


*Figure 1*
*159x119 mm ( x DPI)*