M U N I

COMMENTARY TO HABILITATION THESIS[1]

1.1 Introduction

Catheter ablation of cardiac arrhythmias is an established method of curative treatment of these diseases. Catheter ablation has a significantly higher success rate than pharmacological treatment and is not burdened by a number of complications and side effects associated with the administration of antiarrhythmic and anticoagulant therapy. The success of this method is significantly dependent on the orientation in the heart cavities, which are anatomically complicated and, in addition, interindividually highly variable. Due to the interventional nature of these procedures, non-pharmacological therapy is associated with a number of specific complications, especially in catheter ablation of complex atrial and ventricular arrhythmias. As an example, I can mention the perforation of the heart wall with a subsequent cardiac tamponade or high-grade atrioventricular block. The close relationship between the posterior wall of the left atrium and the esophagus can lead to a rare, but mostly fatal, atrioesophageal fistula. To improve orientation during catheter ablations, three-dimensional (3D) imaging of the heart using various imaging methods and the use of these 3D models to increase the efficiency and safety of catheter ablations is key. At our workplace, we standardly use computed tomography (CT) of the heart and 3D rotational angiography (3DRA) of the left atrium and esophagus to support catheter ablation of arrhythmias, and in recent years we have published a number of papers on the use of these methods in various aspects of catheter ablation of arrhythmias.

1.2 Aims

The habilitation thesis is a commentary on a set of publications containing the issue of supporting catheter ablations of complex atrial and ventricular arrhythmias by 3D X-ray imaging methods, where the applicant is the first author or co-author. The works are organized into 5 chapters according to aims.

Aim 1. To determine the variability of the anatomy of the atria of the heart and the detailed anatomical connection of the left atrium and esophagus.

Aim 2. To determine the effectiveness of using periprocedural 3D imaging of the left atrium and esophagus using 3DRA of these structures in catheter ablation of atrial fibrillation.

[1] The commentary must correspond to standard expectations in the field and must include a brief characteristic of the investigated matter, objectives of the work, employed methodologies, obtained results and, in case of co-authored works, a passage characterising the applicant's contribution in terms of both quality and content.

Aim 3. To determine the radiation exposure when imaging the left atrium using 3DRA and compare with other methods.

Aim 4. To determine the effectiveness of using periprocedural 3D imaging of the right and left ventricles of the heart using 3DRA of these structures in catheter ablation of ventricular arrhythmias.

Aim 5. To determine the variability of the position (mobility) of the esophagus to the left atrium using computer tomography of the heart and 3D imaging of the left atrium and esophagus using 3DRA in patients undergoing catheter ablation of atrial fibrillation.

1.3 Methods

Aim 1. Two works are related to this aim – retrospective evaluation of the position of the esophagus relative to the left atrium in 293 patients undergoing catheter ablation of atrial fibrillation with 3DRA support of the left atrium and esophagus, and detailed analysis of left atrial and esophageal variability from CT examination of the chest in 56 patients undergoing catheter ablation of atrial fibrillation with support of the CT of the heart.

Aim 2. Three original works relate to this objective - a retrospective comparison of different left atrial and esophageal 3DRA acquisition protocols in 547 consecutive patients undergoing atrial fibrillation catheter ablation, a prospective comparison of 3D left atrial models obtained from 3DRA and left atrial CT in 65 patients undergoing catheter ablation of atrial fibrillation examined by both modalities and a retrospective clinical comparison of the efficacy of catheter ablation of atrial fibrillation navigated with support of either left atrial 3DRA or left atrial CT in 125 patients undergoing catheter ablation of atrial fibrillation.

Aim 3. Retrospective comparison of radiation exposure of CT of the heart and 3DRA of left atrium in 157 patients undergoing catheter ablation of atrial fibrillation examined with 3DRA and / or CT of the heart.

Aim 4. Two original works relate to this objective - retrospective evaluation of catheter ablation of 13 patients undergoing catheter ablation of left ventricular arrhythmias with left ventricular 3DRA support, and retrospective evaluation of catheter ablation of right and left ventricular arrhythmias treated with support of left or right ventricular 3DRA in 35 patients.

Aim 5. Two original works relate to this objective - prospective evaluation of long-term mobility of the esophagus towards the left atrium in 56 patients referred to ablation of atrial fibrillation from preprocedural CT data and data from periprocedural 3DRA of the left atrium and esophagus, and prospective evaluation of short-term mobility of the esophagus during

several hours of catheter ablation in 33 patients undergoing catheter ablation of atrial fibrillation from repeated determination of position of the esophagus using 3DRA of left atrium and esophagus and contrast esophagography.

1.4 Results

Aim 1. By evaluating a large number of examinations analyzing the position of the esophagus relative to the left atrium, we found that the position of the esophagus relative to the left atrium is highly variable and the esophagus most often occurs behind the left posterior wall of the left atrium. A detailed analysis of the topographic anatomy of the left atrium and surrounding structures confirmed that the most common position of the esophagus is behind the left posterior wall of the left atrium and the esophagus is in close contact with the left atrium (i.e. separated by less than 4 mm atrium musculature without intervening fat pad on the left atrial cavity) in the upper part of the posterior wall of the left atrium on an area of approximately 2/3 of the length and 1/3 of the width of the posterior wall of the left atrium.

Aim 2. By evaluation of more than 500 3DRAs of the left atrium and esophagus, we found that 3DRA of the left atrium is a reliable and safe method, periprocedural esophageal imaging is simple and safe, and the direct left atrial protocol appears to be the most reliable. We have shown that 3D models of the left atrium created on the basis of 3DRA are comparable with models of the left atrium created from CT data and the results of catheter ablation of atrial fibrillation with support of 3D models of the left atrium from CT data and from 3DRA are comparable.

Aim 3. By comparing the radiation exposure of patients undergoing 3DRA of the left atria and CT of the heart, we found that the radiation exposure of 3DRA is statistically significantly lower than cardiac CT.

Aim 4. By retrospective evaluation of the group of patients undergoing catheter ablation of ventricular arrhythmias with support of 3DRA of left or right ventricle, we found that the use of 3D models of left or right ventricles created by 3DRA is simple and safe and facilitates catheter ablation of ventricular arrhythmias. At the same time, we verified that the direct left ventricular protocol is the most suitable for these purposes.

Aim 5. By prospective evaluation of the difference between the position of the esophagus before ablation (in weeks according to preprocedural imaging of the heart and esophagus by CT) and at the beginning of ablation (according to periprocedural imaging of the left atrium and esophagus by 3DRA) we found that the esophagus is very variable over several weeks and its

preprocedural imaging does not correspond to its position at the beginning of ablation. In contrast, short-term esophageal mobility over several hours of procerude (verified initial 3DRA of the left atrium and esophagus and repeated contrast esophagographies during procedure) is statistically insignificant, and imaging of the esophagus at the beginning of procedure determines its position sufficiently reliably also during procedure.

1.5 Conclusion

Our works supported the importance of 3DRA of the heart and of cardiac CT for the support of catheter ablations of cardiac arrhythmias. Our analysis of the topographic anatomy of the heart and adjacent structures has contributed to the knowledge of the anatomy of this area. By analyzing a large number of 3DRA of atria and ventricles, we verified the most suitable acquisition protocol for individual compartments of the heart. We verified a significantly higher radiation exposure of the CT of the heart compared to the 3DRA of the heart. We have verified that 3DRA of ventricle is a simple and safe method to support catheter ablation of ventricular arrhythmias. We verified that the long-term mobility of the esophagus in the horizon of several weeks before catheter ablation is significant and therefore preprocedural imaging of the esophagus does not make sense. On the contrary, the short-term mobility of the esophagus (change of the position of the esophagus during several hours of the procedure) is insignificant and the display of the esophagus at the beginning of the procedure will allow its localization during the whole procedure.

1.6 Key words

catheter ablation of cardiac arrhythmias; catheter ablation of atrial fibrillation; catheter ablation of ventricular arrhythmias; three-dimensional rotational angiography; computer tomography; three-dimensional representation of the atria; three-dimensional imaging of the ventricles; three-dimensional imaging of the esophagus

[1] ***STAREK, Zdenek***, Frantisek LEHAR, Jiri JEZ, Martin SCUREK, Jiri WOLF, Tomas KULIK a Alena ZBANKOVA. Esophageal positions relative to the left atrium; data from 293 patients

before catheter ablation of atrial fibrillation. *Indian Heart Journal* [online]. 2018, **70**(1), 37–44. ISSN 0019-4832. Dostupné z: doi:10.1016/j.ihj.2017.06.013

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
25	100	85	100

[2] ***STAREK Zdenek***, Lehar Frantisek; Jez Jiri; Wolf Jiri; Kulik Tomas; Kulikova Alena. Detailed analysis of the relationship between the left atrium and esophagus in patients prior to catheter ablation of atrial fibrillation: an analysis using 3D computed tomography. *Biomedical Papers of the Medical Faculty of Palacky University in Olomouc .* 2017 Supplement, Vol. 161, pS42-S49. 8p.

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
20	100	80	100

[3] ***STAREK, Zdenek***, Frantisek LEHAR, Jiri JEZ, Jiri WOLF, Tomas KULIK, Alena ZBANKOVA a Miroslav NOVAK. Periprocedural 3D imaging of the left atrium and esophagus: comparison of different protocols of 3D rotational angiography of the left atrium and esophagus in group of 547 consecutive patients undergoing catheter ablation of the complex atrial arrhythmias. *International Journal of Cardiovascular Imaging* [online]. 2016, **32**(7), 1011–1019. ISSN 1569-5794. Dostupné z: doi:10.1007/s10554-016-0888-y

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15	80	90	100

[4] František Lehar, ***Zdeněk Stárek***, Jiří Jež, Miroslav Novák, Jiří Wolf, Peter Kružliak, Tomáš Kulík, Alena Žbánková, Radek Jančár. Rotational atriography of left atrium – a new imaging technique used to support left atrial radiofrequency ablation: a comparison of anatomical data of left atrium obtained from 3D rotational atriography and computed tomography I*nterv Akut Kardiol* 2013; 12(4): 184–18.

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
30	65	50	90

[5] LEHAR, Frantisek, **Zdenek STAREK**, Jiri JEZ, Miroslav NOVAK, Jiri WOLF, Radka STEPANOVA, Peter KRUZLIAK, Tomas KULIK, Alena ZBANKOVA, Radek JANCAR a Jiri VITOVEC. Comparison of clinical outcomes and safety of catheter ablation for atrial fibrillation supported by data from CT scan or three-dimensional rotational angiogram of left atrium and pulmonary veins. *Biomedical Papers-Olomouc* [online]. 2015, **159**(4), 622–628. ISSN 1213-8118. Dostupné z: doi:10.5507/bp.2014.040

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
40	80	40	80

[6] ***STAREK Zdenek***, Lehar Frantisek; Jez Jiri; Wolf Jiri; Kulik Tomas; Kulikova Alena. Comparison of radiation exposure, contrast agent consumption and cost effectiveness between computer tomography and 3D rotational angiography of the left atrium to guide catheter ablation in patients with atrial fibrillation. *Biomedical Papers of the Medical Faculty of Palacky University in Olomouc .* 2017 Supplement, Vol. 161, pS29-S34. 6p.

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
30	70	75	70

[7] WOLF, Jiri, **Zdenek STAREK**, Jiri JEZ, Frantisek LEHAR, Marketa LUKASOVA, Tomas KULIK a Miroslav NOVAK. Rotational angiography of left ventricle to guide ventricular tachycardia ablation. *International Journal of Cardiovascular Imaging* [online]. 2015, **31**(5), 899–904. ISSN 1569-5794. Dostupné z: doi:10.1007/s10554-015-0636-8

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
50	70	60	100

[8] ***STAREK Zdenek***, Wolf Jiri; Lehar Frantisek; Jez Jiri; Kulik Tomas; Kulikova Alena. Feasibility and safety of right and left ventricular three-dimensional rotational angiography for guiding catheter ablation of ventricular arrhythmias. *Biomedical Papers of the Medical Faculty of Palacky University in Olomouc .* 2017 Supplement, Vol. 161, pS35-S41. 7p.

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
40	70	80	100

[9] ***STAREK Zdenek***, Frantisek LEHAR, Jiri JEZ, Alena ZBANKOVA, Tomas KULIK, Jiri WOLF a Miroslav NOVAK. Long-term mobility of the esophagus in patients undergoing catheter ablation of atrial fibrillation: data from computer tomography and 3D rotational angiography of the left atrium. *Journal of Interventional Cardiac Electrophysiology* [online]. 2016, **46**(2), 81–87. ISSN 1383-875X. Dostupné z: doi:10.1007/s10840-016-0121-x

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
25	100	75	100

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Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
30	100	80	100