Left Atrial Posterior Wall Thickness in Patients with and without Atrial Fibrillation: Data from 298 Consecutive Autopsies.

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Left atrial posterior wall thickness in patients with and without atrial fibrillation: data from 298 consecutive autopsies

Short title: *Left atrial posterior wall thickness and AF ablation*

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Abstract

Introduction: Radiofrequency ablation of atrial fibrillation (AF) is associated with energy delivery on the posterior left atrial (LA) wall with small but significant risk of life-threatening complications. Anatomy of LA walls has been described but wall thickness in patients with AF has not been studied systematically. The aim of the present study was to describe LA posterior wall thickness in patients with and without history of AF.

Methods and Results: Heart mass and LA wall thickness was measured during 298 consecutive autopsies (142 male, age 61±17 years). LA posterior wall was measured at three levels: between the superior pulmonary veins (SPV), in the center of the posterior LA wall (CPV) and between the inferior pulmonary veins (IPV). Information about AF history was obtained from medical records. Fifty nine subjects (20%) had documented AF. They were older than subjects without AF (74±10 vs. 58±17 years, p<0,0001) and had greater heart mass (522±114 vs 389±99 g, p<0,0001). LA posterior wall thickness increased from the most superior to the most inferior measured level (2,3±0,9 vs. 2,5±1,0 vs. 2,9±1,3 mm for SPV, CPV and IPV respectively, p<0,001). Subjects with AF history had thinner LA posterior wall at CPV and IPV compared to those without AF.

Conclusions: LA posterior wall thickness is described on a large series of consecutive autopsies. LA posterior wall is found to be generally thinner in patients with history of AF. Study results have clinical implications for understanding complication risk and improvement of safety of AF ablation procedures.

Key Words: atrial fibrillation, ablation, complications, atrial wall thickness, atrial anatomy

Introduction

Curative catheter ablation of atrial fibrillation (AF) has now spread beyond specialist electrophysiological laboratories and over the last decade has become a standard of care for this arrhythmia. It will certainly become increasingly common after the publication of the Guidelines for the management of patients with AF endorsed by ESC, AHA and ACC in 2006[1] where catheter ablation is considered a legitimate treatment alternative in severely symptomatic patients with either paroxysmal or persistent form of arrhythmia who have failed one or more antiarrhythmic drug therapy.

Left atrial (LA) circumferential ablation aimed at isolation of the pulmonary vein ostia alone or in combination with additional lines in LA has been shown to be one of the most effective approaches to cure AF. Being effective in up to 90% of patients with paroxysmal and up to 80% with persistent AF[2-5], the technique has been associated with a low but not negligible risk of life-threatening and potentially devastating complications associated with delivery of radiofrequency current (RF) including perforation of the LA wall and cardiac tamponade, pulmonary vein stenosis, atrio-esophageal fistula and phrenic nerve injury.

Variation in the thickness of LA wall has to be appreciated when delivering RF energy as the duration and intensity of RF power required to achieve continuous lesion is likely to be lower in the areas with thinner atrial wall. In this regard, the posterior LA wall is particularly important due to its close proximity to the esophagus and periesophageal vagal nerve plexus that can be damaged by the excessive RF power. Limited reports have addressed the issue of LA wall thickness[6, 7] while the number of the heart specimens used in these studies was small.

The objective of our research was to assess LA posterior wall thickness in a large series of consecutive autopsies in regard to the presence of history of AF.

Material and Methods

Measurements of the heart mass and LA wall thickness were performed during consecutive routine autopsies in the tertiary care teaching hospital in St. Petersburg, Russia during 2003-2006. During this period, 298 fresh heart specimens were studied (142 male, mean age 61±17 years). Transmural LA wall thickness was measured from endocardium to epicardium using callipers. Three fixed points on the posterior LA wall were selected for measurements. These were areas that usually receive RF energy during circumferential ablation procedures (Figure 1):

- In the middle of the line connecting the superior pulmonary veins (SPV);
- In the center of the area between the right and left pulmonary veins (CPV);
- In the middle of the line connecting the inferior pulmonary veins (IPV).

Medical records were reviewed with regard to any documented history of AF.

Statistical analysis

All data is presented as mean ± standard deviation from the mean unless stated otherwise. Statistic evaluation was performed using the software StatView 4.5 (Abacus Concepts, Berkeley, CA, USA). The Mann-Whitney U-test was used for comparisons between populations of continuous data. The Wilcoxon signed rank test was used for paired data sets when LA wall thickness at different levels was compared. A P-value less than 0.05 was considered statistically significant.

Results

Demographics

Mean age of the subjects that constituted the study material was 61±17 years. Male subjects were younger than females (56±16 vs. 66±17 years respectively, p<0,001). Based on medical records, fifty nine subjects had documented AF which was diagnosed as permanent in 46. Subjects with history of AF were older than those without arrhythmia (74±10 vs. 58±17 years, p<0,0001).

LA posterior wall thickness

The transmural thickness of the posterior LA wall excluding epicardial fat ranged from 1 to 5 mm superiorly and 1 to 8 mm inferiorly and was decreasing from the most inferior to the most superior measured level (2,9±1,3 vs. 2,5±1,0 vs. 2,3±0,9 mm for IPV, CPV and SPV respectively, p<0,001). The transmural thickness ≤3mm was seen in 87% specimens at SPV, 86% at CPV and 67% at IPV.

Subjects with AF history had generally thinner posterior LA wall at IPV and CPV levels compared with subjects without AF (Figure 2) while heart mass was greater in the AF group (521±114 vs. 388±98 g, p<0,0001). No correlation between the heart mass and the posterior LA wall thickness was observed.

No gender related differences in the LA wall thickness were observed while heart mass was greater in males than in females (428±122 vs. 402±107 g, p<0,001, see also Table 1).

Discussion

Clinical perspective

Atrio-esophageal fistula[4,5] and injury to periesophageal vagal plexus[8] are known complications of the circumferential ablation of AF that are likely to be related to the excessive exposure to radiofrequency current on the posterior LA wall[5]. In a recent study, the distance between the oesophageal wall and posterior LA wall was shown to vary in the interval between 3 and 13 mm depending on the level of measurement in the saggital plane.[9] The space between the posterior LA and esophagus contains parietal pericardium, fat pad with lymph nodes and branches of the left vagal nerve[9]. It has been shown recently that the variable fat layer with mean thickness around 1 mm surrounding esophagus may serve to protect it from thermal injury during the ablation.[10] However, when radiofrequency current is applied to the posterior LA it is likely that the risk of ablative energy penetrating through to the esophagus will depend on its wall thickness. The balance between the amount of energy required for producing transmural lesion in the atrial wall for clinical success and the safety of the procedure is sometimes difficult to achieve. The most common practice to minimize the risk of these rare procedure-related complications is to decrease power delivery, limiting energy to 25 to 35 watts, decrease tissue contact pressure and move the ablation catheter every 10 to 20 seconds.[5] However, knowledge of the exact thickness of the atrial wall in any individual patient at a given point during ablation procedure is still beyond our reach.

Posterior LA wall thickness gradient

The thickness of the posterior LA wall at different levels has been studied in 45 heart specimens fixed in formalin.[9] Our findings on a larger material are in general agreement with the data reported earlier and show that the posterior wall is thickest in the lower part of the

posterior and the thinnest in its higher parts. The absolute values of the wall thickness we present, however, are less than published by Sánchez-Quintana et al.[9] who estimated the transmural wall thickness as 2.5±0.5 mm at the superior level of posterior LA wall, 3.8±0.6 mm at the middle level and 6.5±2.5 mm at the inferior level adjacent to coronary sinus. Our definitions of the superior, middle and inferior levels of measurement are different as we focussed on the area between the pulmonary vein ostia and therefore the inferior level in our study corresponds to the middle level reported by Sánchez-Quintana et al.[9] One of the possible explanations to the differences observed is that, in our study, the measurements were performed on fresh hearts during the *post-mortem* studies without fixation in formalin. It was observed earlier, that formalin-fixed atrial walls may appear thicker than on the fresh specimens.[6] The magnitude of differences between the findings in the two studies can, however, hardly be considered clinically significant and the thinnest area identified between the superior pulmonary veins in independent reports should be regarded as the risk zone during catheter ablation with extra caution applied while delivering radiofrequency energy.

The wide range of LA posterior wall thickness (between 1 and 8 mm in its inferior part) observed in our study and the lack of its correlation with the heart mass and gender illustrates the high interindividual variability of atrial anatomy. Hence, it is still difficult to estimate LA posterior wall thickness in a given patient undergoing RF ablation of AF and the operator should be aware of the possibility that the atrial wall may be extremely thin even in its 'thickest' inferior part.

Atrial fibrillation and the LA wall thickness

Fibrotic changes in the atrial walls is a known age-related phenomenon.[11] However, the differences in atrial wall thickness between the subjects with and without history of AF have not, to the best of our knowledge, previously been reported. This finding should be interpreted

with caution since patients with history of AF were also significantly older than patients without AF and no analysis of underlying disease was possible to evaluate its impact on atrial pathology.

Interestingly, the thinner posterior LA wall observed in the AF group did not correlate with the heart mass which was significantly greater in subjects with AF history. The same gradient of transmural thickness in the saggital plane was observed in the AF subjects thus highlighting the superior part of the LA posterior wall as a potentially vulnerable ablation zone.

Study limitations

The three points on the posterior LA wall selected for measurement of the wall thickness may not be the most clinically relevant for assessment of possible wall damage as it is the border zones between the PVs and the LA posterior wall that are more often targeted during RF ablation. However, we aimed at selecting the locations in the vicinity of the exposed LA wall areas that are easy to identify in all heart specimens and allow robust statistical comparisons in a large material.

Conclusion

In a large series of consecutive autopsies, the mean LA posterior wall thickness measured on fresh heart specimens in the area commonly targeted for circumferential ablation of AF was ≤3 mm in the vast majority. The atrial wall appeared to be generally thinner in patients with history of AF and demonstrated thickness gradient in the saggital plane being thinner at the level of superior pulmonary veins and thicker at the level of inferior pulmonary veins. The area between the superior pulmonary veins is the thinnest on the posterior LA wall and should

be considered the highest risk zone for radiofrequency ablation in regard to the rare but potentially devastating complications caused by thermal injury such as perforation of atrial wall and atrio-esophageal fistula.

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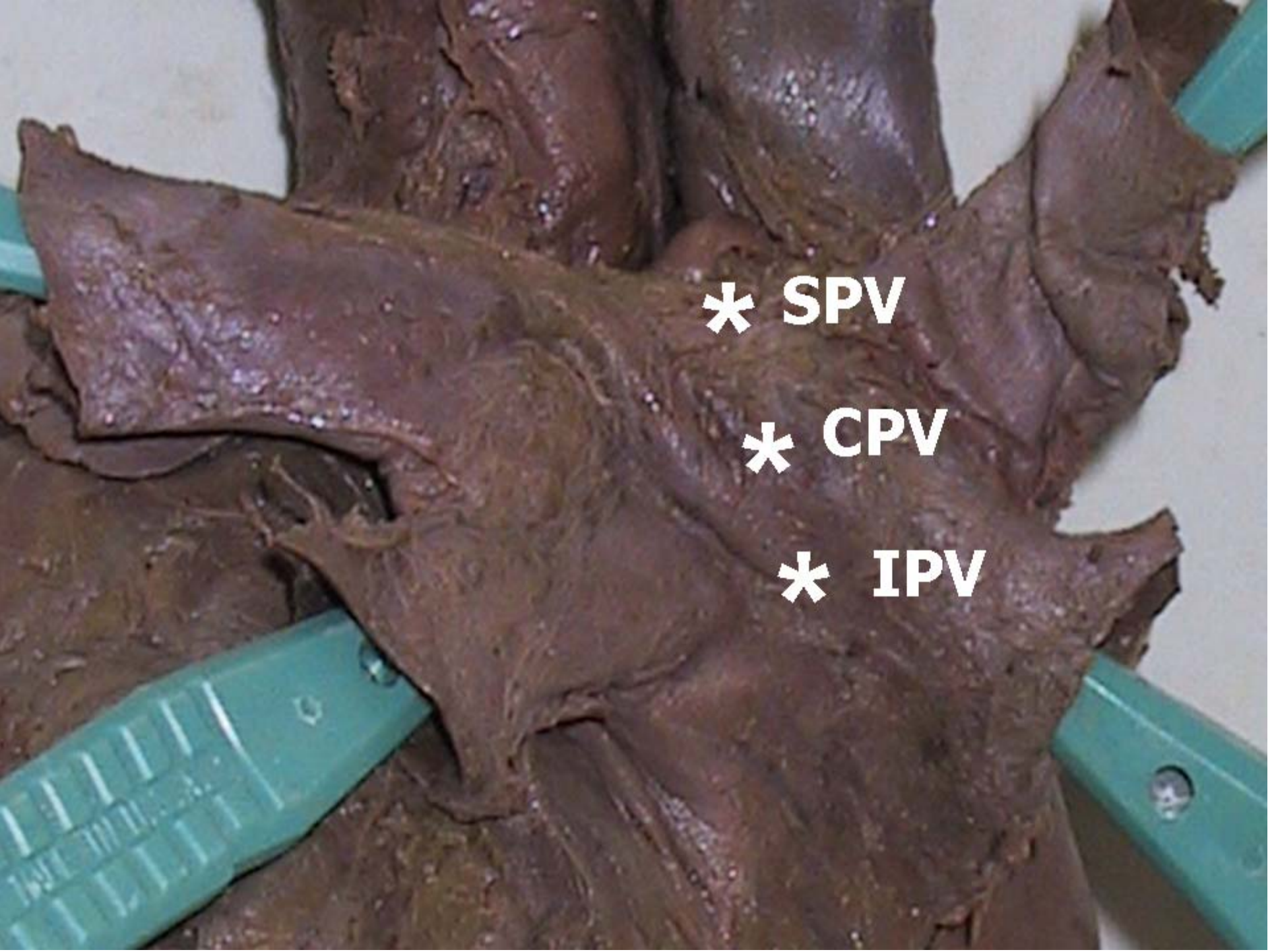
	Males n=142	Females n=155
Age at death*, years	56 ± 16	66 ± 17
Heart mass, g	428 ± 122	402 ± 107
SPV thickness, mm	24 ± 10	22 ± 1,0
CPV thickness, mm	26 ± 10	25 ± 09
IPV thickness, mm	29 ± 14	28 ± 12

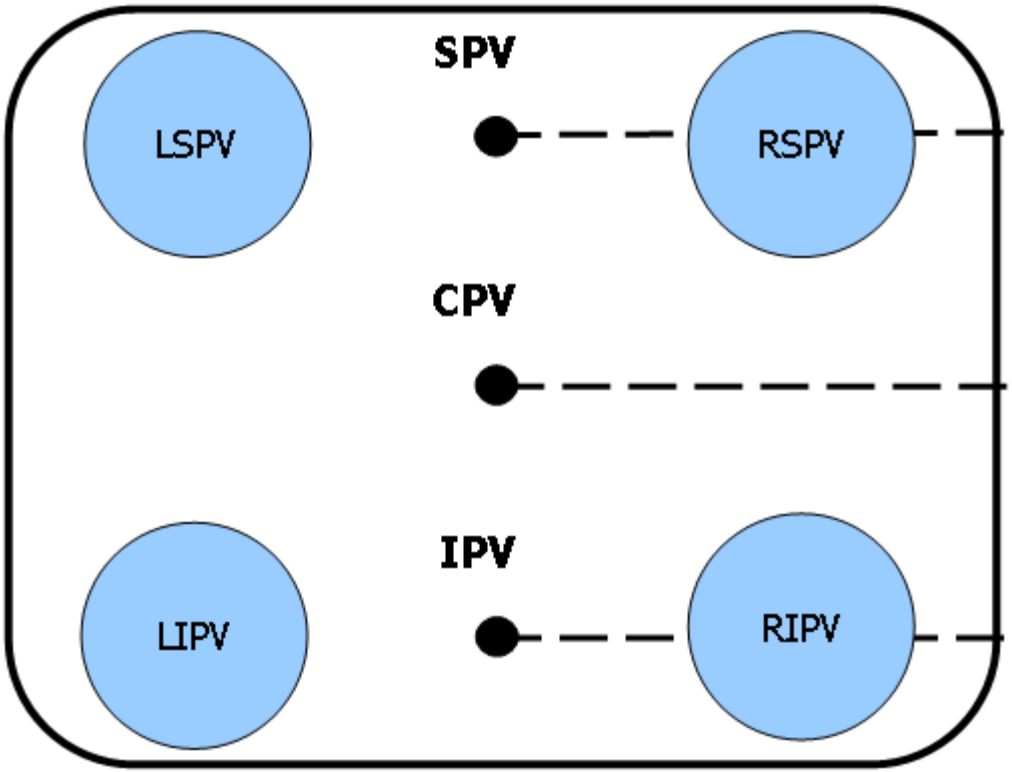
Table 1. Morphometric data in males and females regardless of AF history. All differences are not significant except age at death (*$p<0.001$). CPV – point of measurement in the center between four pulmonary veins ostia; IPV – point of measurement between the inferior pulmonary veins; SPV – point of measurement between the superior pulmonary veins

Legends to the figures

Figure 1. View of the posterior LA wall in a heart specimen. Asterisks indicate points of measurements of LA wall thickness at the level of superior pulmonary veins (SPV), center between the four pulmonary veins ostia (CPV) and inferior pulmonary veins (IPV).

Figure 2. Diagram of the three standard sites where LA wall thickness was measured along the midline between ipsilateral veins. The table presents left atrial posterior wall thickness in mm in patients with and without history of atrial fibrillation. AF – atrial fibrillation, LIPV – left inferior pulmonary vein, LSPV – left superior pulmonary vein, RIPV – right inferior pulmonary vein, RSPV – right superior pulmonary vein, SPV – superior pulmonary veins, CPV – center between four pulmonary veins ostia, IPV – inferior pulmonary veins


* SPV
* CPV
* IPV



	No AF n=239	AF n=59	p-value
SPV	2.3±1.0	2.1±0.9	NS
CPV	2.6±1.0	2.2±1.0	<0.01
IPV	2.9±1.3	2.5±1.3	<0.05