CORRELATION OF RIGHT ATRIAL APPENDAGE VELOCITY WITH LEFT ATRIAL APPENDAGE VELOCITY AND BRAIN NATRIURETIC PEPTIDE

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BACKGROUND: Left atrial appendage (LAA) anatomy and function have been well characterized both in healthy and diseased people, whereas relatively little attention has been focused on the right atrial appendage (RAA). We sought to evaluate RAA flow velocity and to compare these parameters with LAA indices and with a study of biomarkers, such as brain natriuretic peptide, among patients with sinus rhythm (SR) and atrial fibrillation (AF).

METHODS: In a series of 79 consecutive patients referred for transesophageal echocardiography, 43 patients (23 with AF and 20 controls) were evaluated.

RESULTS: AF was associated with a decrease in flow velocity for both LAA and RAA [LAA velocity-SR vs. AF: 61 ± 22 vs. 29 ± 18 m/sec (p < 0.01), RAA velocity-SR vs. AF: 46 ± 20 vs. 19 ± 8 m/sec (p < 0.01)]. Based on simple linear regression analysis, LAA velocity and RAA velocity were positively correlated, and RAA velocity was inversely correlated with brain natriuretic peptide (BNP).

CONCLUSION: AF was associated with decreased RAA and LAA flow velocities. RAA velocity was found to be positively correlated with LAA velocity and negatively correlated with BNP. The plasma BNP concentration may serve as a determinant of LAA and RAA functions.

KEY WORDS: Atrial appendage · Atrial function · Brain natriuretic peptide.
enrolled in our study. Baseline clinical characteristics included age, sex, height, weight, smoking history, and the statuses of various medical conditions including systemic hypertension, diabetes, and hyperlipidemia. We defined hyperlipidemia as a triglyceride level greater than 200 mg/dL or an low-density lipoprotein level greater than 130 mg/dL.

Approval was granted by the institutional review board, and patients were required to provide informed consent.

**Echocardiography**

All patients underwent both transthoracic and multiplane transesophageal echocardiography. The studies were performed with a 3.25-MHz transthoracic transducer (Philips Medical Systems, Andover, MA, USA) with patients in the left lateral decubitus position. Transthoracic echocardiography studies were carried out according to the recommendations of the American Society of Echocardiography. M-mode left atrial (LA) dimension, right ventricular (RV) dimension, and interventricular septal dimension were measured in the parasternal long-axis view at end-diastole. Left ventricular end diastolic dimension, left ventricular end systolic dimension, and ejection fraction were measured in the parasternal long-axis view. Tissue velocities (E and e') were measured at septum in Doppler images, and E/e' was calculated. RV systolic pressure was calculated using the RV-right atrial pressure gradient and tricuspid regurgitation velocity.

Transthoracic echocardiography was performed using a commercial 2-7-MHz multiplane probe (Philips Medical Systems, Andover, MA, USA) after patient fasting. Topical lidocaine spray and viscous lidocaine solution were used to anesthetize the oropharynx before the investigation. The LAA was imaged in the basal short-axis view using a transverse scan from 0 to 45 degrees (Fig. 1). The scanning plane was rotated from 90 to 145 degrees to achieve visualization of the RAA (Fig. 2). Peak LAA and RAA ejection and filling velocities were measured by placing a pulsed wave Doppler sample volume just inside the base of the appendage, as suggested by Fatkin et al.

**Laboratory Measurements**

All blood samples were obtained the day after hospital admission and before transesophageal echocardiogram (TEE). The plasma BNP and high-sensitivity C-reactive protein (hs-CRP) concentrations were measured with an ACCESS 2 produced by Beckman Coulter and an LX20 produced by Beckman Coulter (Brea, CA, USA), respectively.

**Statistics**

Values are expressed as mean ± SD. Continuous variables between groups were compared using student’s t-test. Nominal variables between groups were compared using Chi-square test. Correlations between RAA velocities and LAA velocities and between RAA velocities and BNP were performed with a pearson’s correlation analysis (version 12.0 for Windows; SPSS, Chicago, IL, USA).

**Results**

**Patient Characteristics**

The clinical characteristics for all 43 patients (mean age 64.1 ± 14.3 years), including the AF group and SR group, are shown in Table 1. There were no statistically significant differences in height, weight, or body surface area level between the AF group and SR group. Hypertension, diabetes mellitus, smoking, and hyperlipidemia were more frequently seen in the AF group than they were in the SR group.

**Echocardiography**

The transthoracic echocardiographic (TTE) parameters are listed in Table 2. LA size was significantly larger among patients in the AF group than in the SR group [AF vs. SR: 4.6 ± 0.65 vs. 3.5 ± 0.78 cm (p = 0.00)]. The E/e' value was greater in the AF group [AF vs. SR: 9.35 ± 3.51 vs. 7.35 ± 2.97 (p = 0.02)].
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0.059), but it was not statistically significant. Significant differences were not seen for any other measurements.

LAA and RAA velocities according to TEE were all significantly slower in the AF group compared to those in the SR group (Table 3). The mean LAA ejection velocity (LAA E) was 29 ± 18 cm/sec in the AF group and 61 ± 22 cm/sec in the SR group (p < 0.001), and the mean LAA filling velocity (LAA F) was 33 ± 18 m/sec in the AF group and 58 ± 29 m/sec in the SR group (p < 0.001). The mean RAA ejection velocity (RAA e) and filling velocity (RAA f) were also slower in the AF group than in the SR group [AF vs. SR: 19 ± 8 vs. 46 ± 20 cm/sec (p < 0.001), 22 ± 12 vs. 39 ± 13 cm/sec (p < 0.001)].

**Table 1.** Baseline characteristics between SR and AF groups were compared using t-test and Chi-square test

|                         | Total patients (n = 43) | AF (n = 23) | SR (n = 20) | p value |
|-------------------------|------------------------|------------|------------|---------|
| Age (yr)                | 64.1 ± 14.3            | 64.4 ± 14.6| 62.5 ± 17.7| 0.318   |
| Sex (M/F)               | 25/18                  | 18/5       | 7/13       | 0.012   |
| Height (cm)             | 166.73 ± 8.39          | 167.68 ± 7.9| 165.63 ± 8.9| 0.067   |
| Weight (kg)             | 66.66 ± 16.34          | 69.59 ± 10.59| 63.26 ± 20.97| 0.116   |
| BSA (m²)                | 23.75 ± 4.25           | 24.65 ± 2.76| 21.47 ± 6.85| 0.191   |
| Hypertension (Yes/No)   | 8/35                   | 7/16       | 1/19       | 0.037   |
| Diabetes (Yes/No)       | 3/39                   | 3/20       | 1/19       | 0.359   |
| Smoking (Yes/No)        | 18/25                  | 13/10      | 5/15       | 0.037   |
| Hyperlipidemia (Yes/No) | 11/32                  | 8/15       | 3/17       | 0.128   |

AF: atrial fibrillation, SR: sinus rhythm, BSA: body surface area.

**Biochemical Markers**

There was no statistically significant difference in hs-CRP concentration between the two groups, but the BNP level was higher in the AF group than in the SR group [AF vs. SR: 301.4 ± 286.6 vs. 107.2 ± 158.3 pg/mol (p = 0.016)] (Table 4).

**Table 3.** Comparison of appendage velocity in patients with AF and SR (transesophageal echocardiographic assessment)

|                         | AF (n = 23) | SR (n = 20) | p value |
|-------------------------|------------|------------|---------|
| LAA E* (cm/sec)         | 29 ± 18    | 61 ± 22    | < 0.001 |
| LAA F† (cm/sec)         | 33 ± 18    | 58 ± 19    | < 0.001 |
| RAA e* (cm/sec)         | 19 ± 8     | 46 ± 20    | < 0.001 |
| RAA f (cm/sec)          | 22 ± 12    | 39 ± 13    | < 0.001 |

*Peak emptying velocity, †Peak filling velocity. AF: atrial fibrillation, SR: sinus rhythm, LAA: left atrial appendage, RAA: right atrial appendage.

**Table 4.** Comparison of biochemical markers in patients with AF and SR

|                         | AF (n = 23) | SR (n = 20) | p value |
|-------------------------|------------|------------|---------|
| BNP (pg/mL)             | 301.4 ± 286.6| 107.2 ± 158.3| 0.016   |
| hs-CRP (mg/L)           | 0.74 ± 0.83 | 1.7 ± 3.7  | 0.238   |

AF: atrial fibrillation, SR: sinus rhythm, BNP: brain natriuretic peptide, CRP: C-reactive protein

**Correlations**

BNP concentration was negatively correlated with LAA emptying velocity (r = -0.44; p = 0.01) and with LAA filling velocity (r = -0.39; p = 0.01). BNP expression was also negatively correlated with RAA emptying velocity (r = -0.36; p = 0.02) and with RAA filling velocity (r = -0.34; p = 0.03) (Table 5). RAA velocities and LAA velocities were significantly posi-
and LAA flow velocity. LAA and RAA peak emptying and filling velocities were lower in the AF group compared with those in the control group. These results suggest that AF leads to decrease not only in LA function but also in RA function. The larger E/e’ in the AF group indicates that AF group has worse LV diastolic dysfunction than SR group.

BNP concentration is known to be associated with LA function. In our study, BNP level was correlated with LAA and RAA velocity (emptying and filling). BNP concentration may therefore correlate with RAA function.

There were several limitations to this study. First, we did not observe significant correlations between variables in patients with AF. This lack of significance may be associated with small size of the study group. Second, no hemodynamic parameters like right atrial pressure or right atrial volume were included in the analysis. Third, we could not exclude all possible heart problems which may have affected the SRs of patients used as a control group. Despite these limitations, the results of this study will serve as a very useful reference for future studies about RAA anatomy and function.

In conclusion, AF is associated with depressed RAA and LAA flow velocities and with increased LA size. RAA velocity was found to be positively correlated with LAA velocity and negatively correlated with BNP concentration. Therefore, plasma BNP concentration may serve as a determinant of LAA and RAA functions. Further study is required to determine the clinical significance of RAA.

| Table 5. Correlations between BNP concentration and atrial appendage velocities |
|-----------------|-----------------|
| R               | p value         |
| LAA E           | -0.44           | 0.01 |
| LAA F           | -0.39           | 0.01 |
| RAA e           | -0.36           | 0.02 |
| RAA f           | -0.34           | 0.03 |

LAA: left atrial appendage, RAA: right atrial appendage


diastolic dysfunction and anatomy using TEE, especially peak emptying velocity and peak filling velocity. LAA and RAA peak emptying and filling velocities were lower in the AF group compared with those in the control group. These results suggest that AF leads to decrease not only in LA function but also in RA function. The larger E/e’ in the AF group indicates that AF group has worse LV diastolic dysfunction than SR group.

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