The relation between brain atrophy and poorer hearing was stronger in women with high cognitive function.

Key points
- Women with cortical brain atrophy had poorer hearing in the high-frequency range of the left ear.
- The relation between brain atrophy and poorer hearing was correlated to the extension, not to the location, of the cortical atrophy.
- The relation between brain atrophy and poorer hearing was stronger in women with high cognitive function.

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Conflicts of interest
No conflicts of interest exist.

References

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Tissue Doppler annular velocities, NT-proBNP and exercise capacity in healthy elderly

SIR—The effect of ageing on myocardial function has been evaluated in previous studies using conventional echocardiographic parameters and invasive investigations.
They showed that diastolic left ventricular function decreases with age, while left ventricular systolic function in terms of left ventricular ejection fraction (LVEF) did not seem to be compromised. Pulsed wave tissue Doppler imaging (TDI) allows for better evaluation of diastolic and systolic functions of both ventricles by measuring myocardial velocities of mitral and tricuspid annuli. Early diastolic mitral annular ($E_m$) velocity is a very good predictor of diastolic left ventricular function [1–3]. Left ventricular filling pressure is assessed by calculating the ratio between early mitral valve diastolic velocity ($E$) and $E_m$ velocity ($E/E_m$) [1, 4]. Systolic mitral annular ($S_m$) velocity correlates well with LVEF [5, 6] and recent studies suggest that it is even a more sensitive predictor of left ventricular systolic function than LVEF [7]. Systolic velocity of the tricuspid annulus ($S_t$) is a measure of right ventricular systolic function [8].

It is known that TDI velocities of both annuli decrease with age [6]. The decrease in early diastolic velocities is caused by progressive diastolic dysfunction of both ventricles. The less pronounced decrease of systolic velocities is caused by progressive systolic dysfunction that occurs with ageing despite a preserved LVEF. It is not known whether the decrease in annular velocities associated with ageing is correlated with other parameters of cardiac dysfunction.

N-terminal pro-brain natriuretic peptide (NT-proBNP) is a remnant after cleavage of pro-brain natriuretic peptide to brain natriuretic peptide (BNP). It is secreted mainly by ventricular myocytes [9]. In patients with congestive heart failure, plasma levels of NT-proBNP are elevated and correlate strongly with the NYHA functional status and TDI mitral annular velocities, especially $E_m$ velocity [10, 11]. Plasma NT-proBNP levels increase with age [12].

The mechanisms of exercise intolerance in the elderly are not exactly known. Some investigators suggest that the main causative mechanism of exercise intolerance is an excessive rise in pulmonary capillary wedge pressure [13]. Others think that peripheral factors are also important factors limiting exercise capacity [14]. The role of mitral annular TDI velocities in predicting the level of exercise capacity has been studied in patients with different cardiovascular diseases [13, 15, 16], but has not yet been investigated in healthy elderly subjects.

**Methods**

We studied 30 healthy elderly subjects (15 men) aged 70–95 years, and 30 healthy young subjects (15 men) aged 19–40 years as a control group. All subjects were free of any disease. Plasma creatinine concentrations were measured, and glomerular filtration rate (eGFR) was estimated using the Cockcroft–Gault equation. All subjects underwent standard echocardiographic examination according to published guidelines. A PHILIPS HD 11 XE sector-array system equipped with TDI technology was used. Patients with LVEF of <50% or with dysfunction of any valve greater than mild, were not included in the study. Pulsed wave TDI velocities were measured at the septal and lateral corners of the mitral annulus, and at the lateral corner of the tricuspid annulus in the apical 4-chamber position, with the annulus motion being aligned with the sample volume line. A 5-mm sample volume was used. The main systolic velocity and the early diastolic velocity were measured on-line. During normal breathing, three consecutive beats were averaged.

A mean value measured from the septal and lateral sites of the mitral annulus was calculated. To ensure a more accurate comparison with earlier studies, the ratio $E/E_m$ was calculated using $E_m$ velocity measured at the septal site only.

After the echo, symptom-limited exercise was performed on a cycle ergometer. The maximal oxygen uptake ($VO_{2\max}$) was measured using the Schiller CS 200 metabolic analyser. A test was accepted as a ‘true maximum’ according to published criteria [17]. Subjects who failed to meet these criteria, or had any other pathological findings during exercise stress testing were not included in the study.

NT-proBNP levels were measured in the blood collected by venipuncture in EDTA tubes at the time of echocardiographic exam. The automated electrochemiluminescence immunoassay (Roche–Elecsys 2010, ref. value 0–230.6 pg/ml) was used.

Continuous data are presented as mean ± SD, and categorical data as numbers (percentage). Natural log transformation was used on NT-proBNP levels because of logarithmic distribution. Student’s t-test of unpaired samples was used to compare data obtained in the two study groups. Correlations between continuous variables were determined using linear regression. Data were analysed using the standard statistical software (SPSS version 11.0; SPSS Inc., Chicago, Illinois). A P value of <0.05 was considered significant.

The study was approved by the national medical ethics committee. All subjects gave a written informed consent to participate in the study.

**Results**

The basic clinical, laboratory and conventional echocardiographic data for both study groups are listed in Table 1. A significantly higher systolic blood pressure, and significantly lower blood haemoglobin levels and estimated glomerular filtration rate (eGFR) were found in the elderly. All TDI annular velocities (Table 2), especially $E_m$ velocities, were lower in the elderly. The elderly had significantly higher NT-proBNP levels and significantly lower $VO_{2\max}$. The older group showed a significant positive correlation between $E_m$ velocity and log NT-proBNP ($r = −0.61, P < 0.001$), and $E_m$ velocity and $VO_{2\max}$ ($r = 0.67, P < 0.001$) and a weak significant correlation between log NT-proBNP and eGFR ($r = −0.36, P = 0.04$). There was also a weak but significant correlation between log NT-proBNP and $VO_{2\max}$ ($r = −0.38, P = 0.04$). In the group of younger subjects, no correlation was found between TDI velocities and other variables, but there was a moderate and significant correlation between blood haemoglobin levels and $VO_{2\max}$ ($r = 0.49, P = 0.01$).
Confirmed by showing the decline in echocardiographic criteria \[19\]. In our study, this finding was associated with ageing has already been observed with normal ageing suggests a decline in the elderly.

In conclusion, our results showed that significant left ventricular dysfunction occurs with ageing. As indicated by absolute values of $E_m$ velocities, this dysfunction reaches the degree found in patients with mild chronic heart failure. Left ventricular dysfunction is also associated with neurohumoral activation and rise of plasma NT-proBNP levels and with declining aerobic capacity. These findings suggest that early-stage heart failure is a feature of normal ageing and age-specific cut-offs must be considered when dealing with older patients with unexplained dyspnea or reduced exercise tolerance.

### Discussion

The results of our study show significant correlations between $E_m$ velocity, NT-proBNP plasma level and maximum oxygen uptake in the healthy elderly.

Our results confirmed the findings of earlier studies \[6, 18\] that TDI annular velocities are lower in elderly subjects than in younger individuals. The decline in TDI velocities observed with normal ageing suggests a decline in the function of both ventricles. Diastolic left ventricular dysfunction associated with ageing has already been substantiated in larger-scale studies using conventional echocardiographic criteria \[19\]. In our study, this finding was confirmed by showing the decline in $E_m$ velocity. Absolute $E_m$ velocities were within the range of $E_m$ velocities found in patients with early stages of congestive heart failure in our previous study \[11\]. The decline in $E_m$ velocities suggested some degree of systolic dysfunction although no difference in LVEF was found between the groups studied. Our results accord with the findings of some latest studies suggesting that $E_m$ velocity is a very sensitive marker of left ventricular systolic function, showing left ventricular function as a muscular pump and not only as a haemodynamic pump as does LVEF \[7\].

In our study, the elderly demonstrated higher NT-proBNP plasma levels than the group of younger subjects. This observation is consistent with the results of previous demographic studies showing that NT-proBNP levels rise with age. Investigators proposed two possible mechanisms: diastolic dysfunction and renal failure, both associated with ageing \[12\]. In our group of older subjects, plasma NT-proBNP levels were significantly correlated with $E_m$ velocity and eGFR. The stronger correlation with $E_m$ velocity suggested that left ventricular diastolic dysfunction is the main cause of NT-proBNP rise. The finding accords with the results of previous studies showing good correlation between $E_m$ velocity and NT-proBNP levels in patients with congestive heart failure \[10, 11\].

It is known that exercise capacity declines with ageing, but the causative mechanisms are not yet well understood. Some authors maintain that peripheral factors, such as skeletal muscle dysfunction, ventilatory abnormalities, and endothelial dysfunction, play an important role in limiting exercise capacity \[14\]. On the other hand, many studies using TDI have shown that $E_m$ velocity and $E/E_m$ ratio are the strongest determinants of exercise capacity in different subgroups of patients \[13, 15, 16\]. Our elderly subjects showed a significant correlation between $E_m$ velocity and VO$_{2\max}$. We think that in healthy elderly diastolic dysfunction per se is the main determinant of exercise capacity because there is no contribution of other diseases that cause compensatory increase in left ventricular filling pressure as proposed by Skaluba and Litwin \[13\].

We found no correlation between tricuspid annular velocities and exercise capacity or plasma NT-proBNP level in any of the groups studied. Probably, the role of the right ventricle in healthy individuals is a minor one.

### Table 1. Basic clinical, laboratory and conventional echocardiographic data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elderly (n = 30)</th>
<th>Younger subjects (n = 30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>75 ± 6</td>
<td>30 ± 16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body mass</td>
<td>24.3 ± 3.3</td>
<td>23.8 ± 3.2</td>
<td>0.49</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>133 ± 8</td>
<td>122 ± 17</td>
<td>0.005</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>82 ± 7</td>
<td>77 ± 10</td>
<td>0.07</td>
</tr>
<tr>
<td>Hb (g/l)</td>
<td>139 ± 10</td>
<td>148 ± 15</td>
<td>0.014</td>
</tr>
<tr>
<td>eGFR (ml/min)</td>
<td>51 ± 12</td>
<td>110 ± 26</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>66 ± 5</td>
<td>65 ± 4</td>
<td>0.29</td>
</tr>
<tr>
<td>E (cm/s)</td>
<td>63 ± 14</td>
<td>90 ± 12</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Data are presented as mean ± standard deviation. E$_m$ velocity, TDI derived mitral annular early diastolic velocity; E/E$_m$ ratio, ratio between early diastolic mitral inflow velocity and TDI derived mitral annular early diastolic velocity measured at septal site; $E_s$ velocity, TDI derived mitral annular systolic velocity; $E_t$ velocity, TDI derived tricuspid annular early diastolic velocity; $S$ velocity, TDI derived tricuspid annular systolic velocity; VO$_{2\max}$, maximal oxygen consumption.

### Table 2. Tissue Doppler annular velocities, plasma NT-proBNP levels and maximal oxygen consumption

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elderly (n = 30)</th>
<th>Younger subjects (n = 30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>E$_m$ velocity (cm/s)</td>
<td>6.9 ± 1.3</td>
<td>14.1 ± 1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E/E$_m$ ratio</td>
<td>10.6 ± 2.2</td>
<td>7.8 ± 1.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>$E_s$ velocity (cm/s)</td>
<td>7.8 ± 1.1</td>
<td>10 ± 1.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>$E_t$ velocity (cm/s)</td>
<td>10 ± 1.7</td>
<td>15.6 ± 2.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NT-proBNP (pg/ml)</td>
<td>220.2 ± 195.5</td>
<td>40.7 ± 30.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>VO$_{2\max}$ (ml/kg/min)</td>
<td>22.1 ± 6.1</td>
<td>35.8 ± 6.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Data are presented as mean ± standard deviation. E$_m$ velocity, TDI derived mitral annular early diastolic velocity; E/E$_m$ ratio, ratio between early diastolic mitral inflow velocity and TDI derived mitral annular early diastolic velocity measured at septal site; $E_s$ velocity, TDI derived mitral annular systolic velocity; $E_t$ velocity, TDI derived tricuspid annular early diastolic velocity; S velocity, TDI derived tricuspid annular systolic velocity; VO$_{2\max}$, maximal oxygen consumption.
Normal ageing can be considered as early-stage heart failure. With ageing, there is an increase of plasma NT-proBNP levels and a decline of exercise capacity. Both are correlated with left ventricular diastolic dysfunction that reaches the degree found in patients with mild chronic heart failure.

Normal ageing can be considered as early-stage heart failure.

Key points
- TDI is a powerful echocardiographic tool for assessing the functions of both ventricles. It shows that systolic and diastolic functions of both ventricles decline with normal ageing.
- With ageing, there is an increase of plasma NT-proBNP levels and a decline of exercise capacity. Both are correlated with left ventricular diastolic dysfunction that reaches the degree found in patients with mild chronic heart failure.
- Normal ageing can be considered as early-stage heart failure.

Conflict of interest
There are no conflicts of interest.

References

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Predicting length of hospitalisation of elderly patients, using the Barthel Index

SIR—Short-stay units (SSUs) are an effective and safe alternative to standard inpatient hospitalisation and have managed to reduce length of stay (LOS) among patients who require admission but not to a specialised unit [1, 2]. The average stay must be 4–5 days, so strict admission criteria must be applied [2–4]. Patient age is one of many factors that influence LOS. Elderly patients may also have a lower functional status before illness that warrant admission. We hypothesise that the previous functional status could affect the LOS. Moreover, in-hospital admission is associated with deterioration of previous functional status, and the lack of autonomy could be an inconvenience in accepting discharge.

The Barthel Index (BI) score has proved most useful in patients with stroke [5] and is also recommended in assessing...