

Gender-Specific Echocardiographic Findings in Nonagenarians With Cardiovascular Disease

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Echocardiographic findings in the fastest growing segment of our population, the very elderly, are limited in the literature. We performed a retrospective analysis of 431 consecutive nonagenarians who underwent transthoracic echocardiography (2-dimensional, M-mode, pulse and continuous wave Doppler with color flow mapping) at our center. Mean age was 92.4 years, with women being the majority (73% vs 27%). Men were more likely than women to have coronary artery disease (45% vs 36%, $p = 0.03$), impaired left ventricular (LV) ejection fraction (51% vs 40%, $p < 0.04$), lower mean LV ejection fraction (50% vs 54%, $p = 0.01$), and regional wall motion abnormalities (31% vs 19%, $p = 0.009$). Women were much more likely than men to have hypertension (76% vs 52%, $p = < 0.0001$), LV hypertrophy (82% vs 72%, $p < 0.001$), severe left atrial enlargement (31% vs 16%, $p = 0.004$), moderate to severe mitral annular calcification (22% vs 10, $p = 0.006$), and tricuspid regurgitation (70% vs 51, $p = 0.002$). In this, largest to date, study of echocardiographic findings in nonagenarians, abnormal findings were much more common than previously reported. Men were more likely to have coronary artery disease and related findings, whereas women were more likely to have hypertension and related findings. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;105:273–276)

The very elderly (>85 years of age) constitute a distinct population with a high prevalence of cardiovascular disease. Census statistics demonstrate that the very elderly are the fastest growing segment of the population. The number of very elderly is projected to reach 19 million by 2030, at which time they will constitute 24% of the elderly population and 5% of the entire population.¹ However, our knowledge of the structural and functional cardiac changes in this expanding population remains incomplete. The effects of aging and cardiovascular disease on the heart have been largely examined in autopsy series.^{2–7} A limited number of studies have looked at the effects of cardiovascular disease using standard 2-dimensional echocardiography in the very elderly. Most of these studies have included only a small number of patients >90 years of age. The largest of these studies, the Cardiovascular Health Study, included 838 subjects who were ≥ 75 years of age.⁸ They demonstrated that with increasing age, male gender, presence of coronary artery disease (CAD), and hypertension (HTN), there is an increase in left ventricular (LV) mass, regional wall motion abnormalities, and worsening of LV systolic function. Tunick et al⁹ reported echocardiographic findings in 58 nonagenarians and found that 1/2 of them had LV hypertrophy and enlarged left atria. We intend to analyze the gender-specific echocardiographic findings in nonagenarians with known cardiovascular disease.

Methods

We conducted a retrospective review of all consecutive nonagenarians who underwent transthoracic echocardiography from October 2003 to November 2006 at Creighton University (Omaha, Nebraska). All echocardiograms were interpreted by board-certified cardiologists at our institution. Five hundred eighty-eight nonagenarians underwent echocardiography including 2-dimensional, M-mode, pulse and continuous wave Doppler with color flow mapping. In addition, in 400 patients, diastolic function was assessed using Doppler interrogation of mitral inflow and mitral annulus tissue Doppler imaging. Of the 588 nonagenarians, 157 were excluded from the analysis, leaving 431 patients for the final analysis. Of the 157 patients who were excluded, 74 patients had no medical history available, 60 patients underwent an open-heart surgery, and 23 patients had no history of cardiovascular disease. Measurements were made based on the most recent American Society of Echocardiography recommendations.¹⁰ Statistical analyses were performed using chi-square or Fischer's exact tests (when appropriate) to compare frequencies between men and women and analysis of variance to compare means between the 2 groups using SPSS 17.0 (SPSS, Inc., Chicago, Illinois).

Results

In concordance with previous studies evaluating the very elderly population, women outnumbered men (72% vs 27%). Mean age of the cohort was 92.4 years which was the same for both men and women. HTN was the most common cardiovascular disease, occurring in 70% of nonagenarians. CAD was present in 37%, atrial fibrillation in 36%, pacemaker/implantable cardioverter-defibrillator implantation in

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Table 1
Medical history and medications in nonagenarians

	Men (n = 118)	Women (n = 313)	Total (n = 431)	p Value
Age (years)	92.3	92.4	92.4	0.70
Hypertension	61 (52%)	239 (76%)	300 (70%)	<0.0001
Congestive heart failure	74 (63%)	180 (58%)	254 (59%)	0.38
Coronary artery disease	53 (45%)	105 (36%)	158 (37%)	0.03
Atrial fibrillation	41 (35%)	114 (37%)	155 (36%)	0.82
Hyperlipidemia	15 (13%)	54 (17%)	69 (16%)	0.30
Diabetes mellitus	17 (14%)	39 (13%)	56 (13%)	0.63
Stroke	16 (14%)	41 (13%)	57 (13%)	0.88
Peripheral vascular disease	13 (11%)	22 (7%)	35 (8%)	0.23
Medications				
β blockers	55 (47%)	171 (55%)	226 (53%)	0.16
Furosemide	50 (43%)	173 (55%)	223 (52%)	0.02
Angiotensin converting enzyme inhibitors/angiotensin receptor blockers	45 (39%)	161 (52%)	206 (48%)	0.02
Aspirin	61 (52%)	132 (43%)	193 (45%)	0.08
Digoxin	25 (21)	80 (26%)	105 (25%)	0.38
Calcium channel blockers	19 (16%)	80 (26%)	99 (23%)	0.04
Nitrates	28 (24%)	65 (21%)	93 (22%)	0.51
Hydrochlorothiazide	15 (13%)	69 (22%)	84 (20%)	0.04
Warfarin	17 (15%)	53 (17%)	70 (16%)	0.66
Statins	15 (13%)	44 (14%)	59 (14%)	0.88
Clonidogrel	12 (10%)	29 (9%)	41 (9%)	0.85

17%, hyperlipidemia in 16%, and diabetes in 13% of nonagenarians (Table 1). Women were much more likely than men to be hypertensive (76% vs 52%, $p < 0.0001$). Men were more likely to have CAD compared to women (45% vs 34%, $p = 0.03$). There was no difference in the prevalence of other co-morbidities, including heart failure, atrial fibrillation, diabetes mellitus, hyperlipidemia, peripheral vascular disease, stroke, and chronic kidney disease between men and women. Heart failure was present in 59% of nonagenarians, among whom 45% had normal LV systolic function and the remaining 55% had systolic impairment.

Medication use at the time of echocardiogram was also available and is presented in Table 1. Beta blockers and furosemide were the most prescribed cardiovascular medications, used by more than 50% of nonagenarians.

Echocardiographic findings in our population are listed in Table 2. Most nonagenarians (57%) were found to have normal LV systolic function, defined as an LV ejection fraction $\geq 55\%$. Mean LV ejection fraction in women was significantly higher than that in men (54% vs 50%, $p = 0.01$). Mild, moderate, and severe systolic dysfunctions were present in 17%, 15%, and 10% of nonagenarians, respectively. In addition, 86% of them had a normal LV size as measured by LV end-diastolic diameter. LV hypertrophy was determined by measuring the thickness of the LV septum and posterior wall at end-diastole. Significantly more women had LV hypertrophy compared to men (82% vs 72%, $p < 0.001$). Mean LV septal and posterior wall thicknesses in men were 11.7 and 11.7 mm and those in women were 11.8 and 11.5 mm. Moreover, moderate to severe LV

hypertrophy was seen more frequently in women compared to men.

The greater part (78%) of our nonagenarian population had normal segmental wall motion. However, men were significantly more likely to have regional wall motion abnormalities compared to women (31% vs 19%, $p = 0.009$). Left atrial enlargement was seen in 77% of nonagenarians, almost equally in men and women. Mean left atrial sizes were 47 mm in men and 44 mm in women. However, women were significantly more likely to have severe left atrial enlargement compared to men (31% vs 16%, $p = 0.001$). Right atrial enlargement was also seen equally in men and women (66%). Diastolic function was assessed and reported in 369 nonagenarians. It could not be accurately determined in patients with atrial fibrillation, paced rhythms, and technically difficult and limited studies. Some degree of diastolic dysfunction was found in 76% of nonagenarians with 3/4 of these being mild (grade I diastolic dysfunction).

Structural valvular abnormalities, including sclerotic, stenotic, and regurgitant lesions, were tabulated and analyzed (Table 3). Degenerative changes of aortic and mitral valves were very common in our patient population. Aortic stenosis was identified in 76% of them, almost equally in men and women (75% vs 77%). Mild, moderate, and severe aortic stenoses were found in 53%, 11%, and 12% of nonagenarians, respectively. Mean aortic valve areas in men and women were 1.93 and 1.80 cm^2 , respectively. Mean and peak aortic valve gradients were 10.8 and 18.9 mm Hg in men and those in women were 9.1 and 15.8 mm Hg. Mitral annular calcification was present in 63% of nonagenarians, with women having a slightly higher prevalence than men (57% vs 65%, $p = 0.10$). Women were significantly more likely than men to have moderate to severe mitral annular calcification (22% vs 10%, $p = 0.006$). Mitral stenosis was rare, occurring in <1% of patients.

Regurgitant lesions were classified qualitatively as mild, moderate, or severe. Trace and trivial regurgitant lesions were considered normal for our analysis. We found tricuspid regurgitation to be the most common valvular regurgitation, occurring in 65% of our nonagenarian population. Women were more likely to have tricuspid regurgitation compared to men (70% vs 51%, $p = 0.002$). Mean right ventricular systolic pressure in the 360 nonagenarians in whom it was measured was 46 mm Hg. There was no significant difference between men and women (44 vs 46, $p = 0.31$). In addition, 59% of nonagenarians had mitral regurgitation, with 42% being classified as mild. There was no significant difference between men and women in the occurrence and severity of mitral regurgitation. Aortic regurgitation was present in 28% of our study population equally in men and women.

Discussion

The very elderly constitute an increasing proportion of the population with considerable cardiovascular disease prevalence. Identifying the common echocardiographic findings in this population and their correlation with type of disease provides the clinician with a better understanding of the disease process. Very few previous studies have described

Table 2
Echocardiographic findings in nonagenarians

	Men (n = 118)	Women (n = 313)	Total (n = 431)	p Value
Left ventricular ejection fraction >55%	58 (49%)	189 (60%)	247 (57%)	0.04
Mild impairment (45–54%)	22 (19%)	52 (17%)	74 (17%)	
Moderate impairment (30–44%)	21 (18%)	46 (15%)	67 (16%)	
Severe impairment (<30%)	17 (14%)	26 (8%)	43 (10%)	
Mean left ventricular ejection fraction (%)	50	54	53	0.01
Mean left ventricular septal thickness (mm)	11.7	11.8	11.8	0.83
Mean left ventricular posterior wall thickness (mm)	11.7	11.5	11.6	0.71
Left ventricular hypertrophy	85 (72%)	256 (82%)	341 (79%)	<0.001
Mild	59 (50%)	156 (50%)	215 (50%)	
Moderate	24 (20%)	73 (23%)	97 (23%)	
Severe	2 (2%)	27 (9%)	29 (7%)	
Left ventricular dilatation	15 (13%)	46 (15%)	61 (14%)	0.59
Regional wall motion abnormalities	36 (31%)	59 (19%)	95 (22%)	0.009
Mean left atrial size (mm)	46.7	44.4	45.1	0.02
Left atrial enlargement	92 (78%)	239 (76%)	331 (77%)	0.72
Mild	38 (32%)	70 (22%)	108 (25%)	
Moderate	35 (30%)	71 (23%)	106 (25%)	
Severe	19 (16%)	98 (31%)	117 (27%)	0.001
Right atrial enlargement	70 (59%)	213 (68%)	283 (66%)	0.08
Diastolic dysfunction	70/100 (70%)	209/269 (78%)	279/369 (76%)	0.86
Right ventricular systolic pressure (mm Hg)	43.9	46.2	45.7	0.26

Table 3
Valvular findings in our nonagenarian cohort

	Men (n = 118)	Women (n = 313)	Total (n = 431)	p Value
Aortic stenosis	88 (75%)	240 (77%)	328 (76%)	0.64
Mild	57 (48%)	171 (55%)	228 (53%)	
Moderate	13 (11%)	35 (11%)	48 (11%)	
Severe	18 (15%)	34 (11%)	52 (12%)	
Aortic valve area (cm ²)	1.93	1.80	1.84	0.16
Peak aortic valve gradient (mm Hg)	18.9	15.8	16.6	0.15
Mean aortic valve gradient (mm Hg)	10.8	9.1	9.5	0.16
Aortic regurgitation	33 (28%)	88 (28%)	121 (28%)	0.97
Mitral annular calcification	67 (57%)	204 (65%)	271 (63%)	0.10
Mild	55 (47%)	136 (44%)	191 (44%)	
Moderate	10 (9%)	54 (17%)	64 (15%)	
Severe	2 (2%)	14 (5%)	16 (4%)	
Mitral regurgitation	67 (57%)	187 (60%)	254 (59%)	0.58
Tricuspid regurgitation	60 (51%)	219 (70%)	279 (65%)	0.002

the echocardiographic findings and cardiovascular disease processes in this important group of the population.

Kitzman,³ in his review, found that age-related changes in the heart included an increase in LV mass, LV wall thickness, and left atrial size. Alterations in diastolic filling were also common. These conclusions were primarily based on autopsy findings or echocardiographic findings in a relatively younger population (<85 years of age). Gardin et al⁸ in the Cardiovascular Heart Study reported that LV mass, impaired LV systolic function, and regional wall motion abnormalities positively correlated with increasing age, male gender, and presence of CAD and HTN. Although there were >800 patients >75 years of age, the number of them >90 years old was not specified. Aronow et al¹¹

reported echocardiographic findings in approximately 1800 patients in a long-term facility. They found that older men were more likely to have abnormal LV ejection fraction compared to older women. They also reported that older women were more likely to have mitral annular calcification, rheumatic mitral stenosis, and left atrial enlargement compared to older men. All subjects in this study were >60 years of age but the number of them >90 years of age was not identified. Tunick et al⁹ reported echocardiographic analysis in 58 nonagenarians. They found that 71% had normal or above normal LV systolic function, 52% had LV hypertrophy, 31% had aortic stenosis, and nearly 1/2 of them had an enlarged left atrium. In these reports, the cardiovascular disease prevalence in the population studied was not mentioned and, hence, no definite conclusions can be made about the clinical significance of the echocardiographic findings.

Nevertheless, in concordance with the previous reports, most nonagenarians in our report had normal LV ejection fraction (57%). Overall, men had a significantly lower LV ejection fraction compared to women (50% vs 54%, $p = 0.01$), as may be expected with the slightly increased prevalence of CAD in men (45% vs 34%, $p = 0.03$). In addition, although a majority of the patients had normal regional wall motion (78%), men were significantly more likely to have regional wall motion abnormalities compared to women (31% vs 19%, $p = 0.009$). This finding is consistent with the previous studies and is likely a reflection of higher prevalence of CAD in men.⁸ However, LV hypertrophy was found to be more common (79%) than previously reported (50%). This may in part be due the advanced age of our study population. Moreover, women were significantly more likely to have LV hypertrophy compared to men (82% vs 72%, $p < 0.001$), which correlates with the

higher prevalence of HTN in women compared to their male counterparts.

Fifty-nine percent of nonagenarians had a diagnosis of heart failure. Approximately 46% of these had a normal LV ejection fraction, which is consistent with the previous findings by Aronow et al.¹² Left atrial enlargement was found to be more common (77%) than previously reported by Tunick et al.⁹ (50%), which may be a reflection of advanced age and probably a high prevalence of cardiovascular disease in our nonagenarian population. Moreover, women were more likely to have severe left atrial enlargement compared to men, which also may be a reflection of the higher prevalence of HTN in women. This finding is consistent with the report by Aronow et al.¹¹ who found a significantly higher prevalence of left atrial enlargement in women >60 years of age compared to men in the same age group. We also analyzed LV diastolic dysfunction. Approximately 77% of our nonagenarians were reported to have diastolic dysfunction, with the majority having grade I dysfunction. This degree of dysfunction can probably be a reflection of the age-related changes in the elderly as reported in previous studies in addition to the high prevalence of HTN.^{3,13}

Degenerative changes such as aortic sclerosis, aortic stenosis, and mitral annular calcification were found to be more prevalent in our patient population than in previous reports.^{11,14} This may be a reflection of their advanced age. We did not find any difference in the prevalence of aortic sclerosis, aortic stenosis, aortic regurgitation, and mitral regurgitation between men and women. This finding is consistent with that reported by Aronow et al.¹¹ More than 75% of our nonagenarian population had aortic stenosis and an additional 20% had aortic sclerosis. In approximately 70% of nonagenarians who had aortic stenosis, it was of mild severity. Mitral annular calcification was present in 63% of our population, with women being much more likely to have more severe (moderate and severe) calcification compared to men (22% vs 10%, $p = 0.004$). Aronow et al.¹¹ reported a similar finding of a significantly higher prevalence of mitral annular calcification in women compared to men. Mitral and tricuspid regurgitant lesions were also more common in our patient population than that reported in previous studies.^{3,9,11}

In summary, in this largest-to-date study of echocardiographic findings in nonagenarians, abnormal findings were much more common than previously reported. Men were more likely to have CAD, impaired LV systolic function, and regional wall motion abnormalities. Women were more likely to have HTN, LV hypertrophy, and tricuspid regurgitation. Most echocardiographic findings are likely a reflection of disease process but the differential affect of age on gender cannot be ruled out.

Limitations: The biggest limitation of our study is its retrospective nature. Our study population may not be rep-

resentative of the very elderly in the general community because they were referred to our cardiology practice by their primary care physician for cardiac evaluation. Approximately 20% of our echocardiographic studies were technically difficult and the accuracy of the findings can be questioned. Last, but not least, it is likely that some of our findings are a result of aging rather than a disease process. However, obtaining echocardiographic findings of a random sample of very elderly citizens without known cardiac disease and comparing them to our findings and those of others would help to delineate the same.

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