The Dutch experience of open access echocardiography

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Cardiac disease is not easy to recognise in general practice. An echocardiogram is an excellent way to provide information about left ventricular mass and diastolic (dys)function and the presence of valvular heart disease. To improve diagnostic care of cardiac patients, an open access echocardiography service was established in the referral area of our hospital, where general practitioners were able to ask for an echocardiogram without referring the patient to the cardiologist. Between December 2002 and October 2006 echocardiograms were requested for 471 patients. Thirteen percent of the patients referred for dyspnoea and 3% of patients with a cardiac murmur had a left ventricular ejection fraction <40%. In 28% of patients no cardiac abnormality could be found. If we looked at the prevalence of hypertension in the referred patients, this was very high with a prevalence of up to 60% in the older age groups. If we included hypertension in the analysis, only 16% of patients had no structural cardiac or vascular abnormality. The study shows that the advantage of open access echocardiography in the Netherlands is that the general practitioner is able to make a better

diagnosis and unnecessary referrals of patients with suspected cardiac disease can be avoided. (*Neth Heart J* 2007;15:432-7.)

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Due to the ageing population, the general practitioner will see more patients with symptoms of dyspnoea.^{1,2} For the general practitioner, with his limited diagnostic facilities, it is frequently very difficult to distinguish between dyspnoea due to cardiac and non-cardiac causes.³ Dyspnoea can be due to systolic or diastolic dysfunction, but can also be caused by pericardial disease, hypertension and non-cardiac abnormalities.

Often, a normal electrocardiogram or a low brain natriuretic peptide (BNP) level can exclude left ventricular dysfunction. Unfortunately, the positive predictive value of both methods is not very high.^{4,5} Electrocardiograms have a positive predictive value of 35% and a negative predictive value of 98% to detect or exclude heart failure. Measurement of plasma BNP gave a positive predictive value of 5 to 38% depending on the cut-off point and a negative predictive value of 92 to 100% in the Framingham Heart Study.⁵ If there is still doubt about the aetiology of dyspnoea, echocardiography can help to differentiate between a cardiac cause and a non-cardiac cause. Besides this, it can also provide information about structural abnormalities that cause dyspnoea in certain patients. In an older population, not only the number of patients with heart failure increases, but also the incidence of hypertension and murmurs of unknown aetiology will rise. A correct diagnosis is not easy despite an extensive physical examination and auscultation.^{6,7} Therefore, in the very south-east of the Netherlands (the Parkstad area) general practitioners were given the opportunity to ask for an echocardiogram without referring the patient to the department of cardiology. This was for

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Table 1. Grading of diastolic dysfunction.^{13,14}

Age group (years)	20-29	30-39	40-49	50-59	60-69	>70
E/A ratio	2.08	1.75	1.44	1.29	1.03	0.84
Standard deviation	0.55	0.4	0.26	0.28	0.26	0.29

The E/A ratio is the ratio of the pulsed wave diastolic flow velocity across the mitral valve and is an indicator of diastolic function. The values are shown here in separate age cohorts.

the indications of dyspnoea, cardiac murmur and peripheral oedema of unknown aetiology. The project was started in December 2002.

Methods

General practitioners who participated in the project were able to ask for an echocardiogram without referring the patient to a cardiologist if they suspected that the patient had heart failure or a cardiac murmur. After a short instruction about the indications and restrictions for referral and the interpretation of the results, the general practitioners were able to refer patients. The rules were that the general practitioners could only ask for an echocardiogram if they had provided the cardiologist with information about the indication, the current medication of the patient and the results of the physical examination.

In order to avoid a large number of requests for echocardiograms, the indications were restricted to dyspnoea, cardiac murmur and peripheral oedema of unknown origin. In general, the echocardiogram was carried out within one week of the request and interpreted according to the criteria of the American and European Societies of Echocardiography.⁸⁻¹¹

During the duration of the study, the diagnostic centre was a separate unit of a large community hospital which only did the logistics for the different laboratories on the request of the general practitioners. The echocardiograms were always performed by a physician, either a cardiologist with extensive experience in cardiac imaging or a fellow in cardiology under supervision of a staff cardiologist. The echocardiograms were performed on a Philips SONOS 5500 system and stored on the ENCONCERT digital storage and retrieval system.

Hypertension was defined as a systolic blood pressure >140 mmHg and a diastolic blood pressure >90 mmHg.¹² Left ventricular dysfunction was defined as a left ventricular ejection fraction <40%. Quantitation of the echocardiograms was performed according to Simpson's rule. Diastolic dysfunction was identified by measurement of the pulsed wave Doppler tracing at the tips of the mitral leaflets and the pulsed wave Doppler of the pulmonary vein flow. Diastolic dysfunction was graded in dysfunction grade 1 to 4 according to the guidelines of the American Society of Echocardiography. As it was detected, the mitral flow pattern was corrected for age as described

previously (table 1).^{13,14} The parameters were corrected for age. The mean value $\pm$ standard deviation was taken as normal for each age group.

Left ventricular hypertrophy was defined as a left ventricular mass according to Devereux's method and indexed for length exceeding 143 g/m for males and 102 g/m for females.¹⁵⁻¹⁷ Pulmonary hypertension was present if the measured systolic pulmonary pressure was >35 mmHg. Aortic insufficiency was measured using the criteria of Perry and Reynolds.^{18,19} Aortic valve insufficiency was assumed to be significant if it was more than grade 2. Aortic valve stenosis was assumed to be clinically important if the maximal gradient was >30 mmHg or the mean gradient >20 mmHg. If one of these criteria was present, the patient was assumed to have significant aortic valve disease. The same criteria were used to define a clinically important left ventricular outflow tract gradient.

Mitral valve insufficiency was graded by measurement of the jet area and proximal jet width at the vena contracta in addition to the measurement of the continuous wave flow and the pulsed wave flow in the pulmonary veins.

Mitral valve regurgitation was assumed to be significant if leakage was more than grade 2. Mitral valve stenosis was assumed to be haemodynamically important if the maximal gradient was ≥ 10 mmHg. If one or more criteria were present the patient was assumed to have significant mitral valve disease.

Pulmonary valve stenosis was considered significant if the maximal measured gradient was >15 mmHg. Pulmonary valve regurgitation was assumed to be haemodynamically important if the leakage was more than grade 2.

The results of the echo Doppler examination were returned to the general practitioner with a comment on how to deal with the patient. Generally, the general practitioner was left free to refer the patient to a cardiologist or treat the patient himself. However, if the cardiac echo examination showed severe abnormalities the general practitioner was advised to refer the patient.

Mean values for each group were compared by using the Student's t-test for continuous variables and the Fisher's test for categorical variables. Continuous variables were expressed as mean $\pm$ SD. Frequencies of categorical variables were defined as percentages (%). In the cohort analysis patients <40 years of age

Figure 1. Indications for referral by the general practitioner. From the group with more than one indication for referral, half were referred for dyspnoea and a cardiac murmur and the other half for dyspnoea and peripheral oedema.

were compared with patients ≥ 40 years using t-test with unequal variances.

Results

Between December 2002 and October 2006 an echocardiogram was requested for 471 patients, 191 (41%) males and 280 (59%) females. The youngest patient was 5 years old and the oldest patient was 95 years. A total of 384 patients (82%) had only one reason for referral. Of these, 201 patients were referred for a cardiac murmur, 107 for dyspnoea, seven for peripheral oedema, and 69 for other reasons. Eighty-three patients (18%) had a double reason for referral, and four patients (1%) had a triple diagnosis. Five patients had another reason for referral (see figure 1).

Clinical characteristics

The mean age of the patients referred for analysis of dyspnoea was 71 years with a range of 31 to 94 years. The mean age of the patients referred for analysis of a cardiac murmur was 58 years with a range of 5 to 95 years for patients without symptoms and 72 years with a range of 31 to 92 years for symptomatic patients ($p < 0.001$ for patients with asymptomatic cardiac murmurs vs. symptomatic cardiac murmurs and patients with dyspnoea).

Physical examination by the general practitioner

For analysis, only those patients who were referred for one reason were included: either shortness of breath or a cardiac murmur.

In patients referred only for dyspnoea, the average blood pressure was 145/83 mmHg. Of these 54 (50%) fulfilled the criteria for hypertension. Systolic hyper-

tension was present in 52 patients (48%), diastolic hypertension in 17 patients (16%). In five of these patients (5%) the central venous pressure was reported to be elevated. A systolic cardiac murmur was reported in nine patients (8%) and a diastolic murmur in two patients (2%).

The patients for analysis of an asymptomatic cardiac murmur had an average blood pressure of 147/82 mmHg. Of these patients 97 (48%) fulfilled the criteria for hypertension. Systolic hypertension was present in 95 patients (47%) and diastolic hypertension in 29 patients (14%). In 162 (81%) of these patients a systolic murmur was reported. In five patients (2%) a diastolic murmur was reported. In the other patients no murmur was reported by the general practitioner.

Sixty-eight patients were referred with a symptomatic murmur. In those patients, the average blood pressure was 151/83 mmHg (not significant to asymptomatic patients).

Only four patients were referred for analysis of peripheral oedema alone. Because of the low number of patients, no analysis was performed.

If we look at the prevalence of hypertension in ten-year cohorts, there was a remarkable increase in hypertension after 40 years of age (table 2). Before 40 years of age, less than 30% of patients had hypertension, whereas after that age the prevalence was far beyond 40% ($p < 0.001$).

Diagnosis after the echocardiogram

The final diagnosis, as it was reported to the general practitioner, can be seen in table 3. Of all patients referred for dyspnoea ($n=185$), including those with an additional murmur, peripheral oedema or other

Table 2. Prevalence of systemic hypertension in patients referred for open access echocardiography separated into ten-year cohorts.

Age cohort	0-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90+	P value
Hypertension (%)	10	13	29	45	51	64	60	61	37	<0.001

* The p value separates patients <40 years of age compared with patients ≥ 40 years.

Table 3. Post-echocardiographic prevalence of cardiac disease separated into ten-year cohorts.

Age cohort (years)	0-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90+	All age groups	P value
LVH	5	33	25	49	57	51	59	48	50	49	<0.001
LVEF ≤40%	0	0	0	0	13	8	7	11	12	7	<0.001
DD	5	20	25	58	59	32	20	22	37	32	<0.001
AVD	0	7	0	2	7	8	14	18	12	9	<0.001
MVD	0	13	4	6	4	3	8	6	0	5	ns
PH	0	0	4	11	13	15	20	28	25	16	<0.001
Any disease without HT	10	53	43	81	83	76	77	74	87	72	<0.001
Any disease involving SHT	20	53	43	81	83	76	77	74	87	84	<0.001
Patients (n)	20	15	28	53	54	117	122	54	8	471	

LVH=left ventricular hypertrophy, LVEF <40%=systolic dysfunction, DD=diastolic dysfunction, AVD=significant aortic valve disease, MVD=significant mitral valve disease, PH=pulmonary hypertension, (S)HT=(systemic) hypertension. The p value separates patients <40 years of age compared with patients ≥40 years. Numbers are percentages, unless stated.

abnormalities, 24 patients (13%) had left ventricular systolic dysfunction defined as a left ventricular ejection fraction <40%. In those patients who were only referred for dyspnoea 16% had left ventricular dysfunction, whereas left ventricular dysfunction was only detected in 8% of patients with dyspnoea and a cardiac murmur ($p<0.001$).

Diastolic dysfunction was present in 37% of patients referred for dyspnoea. There was no difference between the patients referred for dyspnoea alone (36% had diastolic dysfunction) and the patients with a double reason for referral (40% with diastolic dysfunction). Left ventricular hypertrophy was present in 62% of patients referred for dyspnoea alone. This corresponds with the high number of hypertensive patients in our study population.

Pulmonary hypertension was found in 30% of patients referred for dyspnoea. In the whole group of patients referred for dyspnoea, 8% had significant aortic valve disease. In the group referred for dyspnoea alone, aortic valve disease was present in 2% of the patients; in the group referred for dyspnoea and a cardiac murmur or peripheral oedema, aortic valve disease was present in 24% of the patients ($p<0.0001$). In the whole group of patients referred for dyspnoea, 3% had significant mitral valve disease. Mitral valve disease was present in 2% of patients referred for dyspnoea alone and 5% of patients referred for dyspnoea and a cardiac murmur or peripheral oedema ($p<0.001$).

Of all patients referred for a cardiac murmur ($n=269$), 201 patients were asymptomatic and 68 were symptomatic. Of all patients, 16% had significant aortic valve disease, and 7% significant mitral valve disease. Three percent of the patients had significant pulmonary valve disease. A significant LVOT gradient >30 mmHg was found in 1% of the patients. Two percent of the patients

referred for a cardiac murmur had significant tricuspid valve disease and 3% had systolic dysfunction. Diastolic dysfunction was present in 30% of these patients. Left ventricular hypertrophy was found in 45% of the patients referred for a cardiac murmur. This was not significantly different to the percentage found in patients referred for dyspnoea. Pulmonary hypertension was found in 24% of the patients referred for a cardiac murmur.

If we look at the separate age cohorts we again see remarkable differences between the separate age groups as is shown in table 3. As is shown, in agreement with the prevalence of hypertension, the percentage of patients with left ventricular hypertrophy rose significantly after the fourth decade to more than 50% ($p<0.001$). Left ventricular dysfunction was only present in a minority of patients and then only after the fourth decade ($p<0.001$). As we expected from the prevalence of systemic hypertension and left ventricular hypertrophy, diastolic dysfunction had a high prevalence, which was up to 60% in the fourth and fifth decade ($p<0.001$). Valvular heart disease was only present in a minority of patients, and then in general after the age of 40 years. Only aortic valve disease was more prevalent after the age of 40 ($p<0.001$). The prevalence of mitral valve disease did not increase. If we look at the whole population of 471 patients referred for open access echocardiography, no structural cardiac abnormality excluding hypertension could be detected in 132 patients (28%). If we include hypertension only 16% of patients had no structural cardiac or vascular disease.

Discussion

An 'open access echocardiography service' has been developed in the United Kingdom to give the general practitioner the opportunity to ask for an echocardiogram without referring the patient to the

cardiologist. The history and physical examination are performed by the general practitioner and not by the cardiologist.²⁰ In the United Kingdom the service has been very successful in detecting left or right ventricular dysfunction and the aetiology of cardiac murmurs.²¹ The echocardiogram frequently gives the general practitioner additional information with minor discomfort for the patient and low costs.²² A possible disadvantage could be overload of the department of echocardiography if strict criteria for referral are not applied. Because healthcare systems differ among countries, this system can not be used in the same format throughout the world. However, our study has shown that the service can also be applied in the Dutch healthcare system. In our setting, the echocardiography service was limited to patients with dyspnoea, cardiac murmurs and peripheral oedema according to the guidelines from the United Kingdom.²³

The percentage of patients with systolic dysfunction was lower than the number described in a recent study from the United Kingdom.²⁴ A possible reason is that in studies from the United Kingdom patients suspected of having heart failure were preselected by an electrocardiogram. A normal ECG was found to be very sensitive in excluding heart failure in some studies.^{4,25} However, a recent meta-analysis showed a limited accuracy of the ECG as a screening tool.²⁶ An attractive option for pre-selection of patients with dyspnoea would be the use of brain natriuretic peptide as a screening tool, which could be cost-effective as has been shown recently.^{5,27,28} A third possibility would be to teach general practitioners to take the echocardiograms themselves. With the currently available hand-held echocardiography equipment a trained physician is able to detect cardiac pathology with high sensitivity.²⁹ The relatively high number of patients with diastolic dysfunction could be explained by the high percentage of patients with hypertension. The prevalence of hypertension was comparable with the prevalence of hypertension in non-Hispanic white men in the NHAHES survey.³⁰ The presence of left ventricular hypertrophy is clinically important because it is associated with increases in the incidence of heart failure, ventricular arrhythmias, death following myocardial infarction, decreased LV ejection fraction, sudden cardiac death, aortic root dilation, and a cerebrovascular event. An echocardiogram in these patients makes sense.³¹ To detect left ventricular hypertrophy, echocardiography is the procedure of choice, since the sensitivity of the different ECG criteria may be as low as 7 to 35% with mild LVH and 10 to 50% with moderate to severe disease.³²

Analysis of a cardiac murmur was a second indication for referral. Of these patients, 28% had a completely normal echocardiogram. Severe pathology was only found in a minority of patients. The fear of overload of the echo lab was unjustified as these echocardiograms were only 1% of the yearly echo production.

Concluding, one can say that under strict conditions open access echocardiography is a useful service for general practitioners. However, the differences in healthcare systems in European countries make it difficult to translate the results to other systems. To prevent excessive patient load of the service, rules have been established.²³ Within the described conditions, open access echocardiography can improve diagnosis and treatment of patients with heart failure, valve disease and other cardiac diseases, such as atrial fibrillation, with limited costs.

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