

## Cardiac risk assessment in Vascular disease

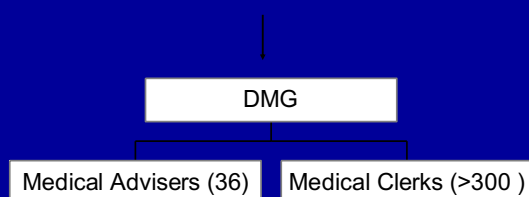


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## DVLA



The Medical Advisers at DVLA (on behalf of Department of Transport UK) are responsible to ensure that all UK Licence holders (groups 1 and 2) are

**FIT to DRIVE**

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## Drivers Medical Group

- Public Health Role
- To promote road safety through the application of the regulations and recommended licensing standards
- To minimise a foreseeable excess risk (risk refers to public risk not just individual risk)

The above is undertaken by assessment of over 500,000+ medical cases annually across a wide range of medical conditions

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## Honorary Medical Advisory Panels

- Appointed by Secretary of State
- Practising clinicians with expertise in relevant area of medicine
- Meet 6 monthly to advise on medical fitness standards in line with latest clinical practice, research developments etc.
- Consider exceptional cases on individual basis

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## Relevant Legislation

- 2<sup>nd</sup> EC Directive 1996
- Road Traffic Act 1988 & Amendments
- The Motor Vehicles (Driving Licences) Regulations 1999
- Annex 3, EC Directive 2009
- Other factors
  - Human Rights Act
  - Disability Discrimination Act
  - GMC Guidance on Confidentiality

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## Driving Standards

Assessing Fitness to Drive [www.dvla.gov.uk](http://www.dvla.gov.uk)

- 2 Main issues in setting standards
  - What is the risk of a sudden and disabling event ?
  - Is the medical condition likely to render the person a source of danger whilst driving

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## Concept of Acceptable Risk

**Group 1:** 20% or less risk per annum of sudden and disabling event.

**Group 2:** 2% or less risk per annum of a sudden and disabling event.

- Higher medical standards apply
  - Size and weight of Vehicle driven commercially
  - Length of time spent behind the wheel
- In >90% of RTA which involve a large vehicle the deaths occur outside the index vehicle.

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## ILO/IMO Guidance for the Medical Examination of Seafarers MSN 1886

### Cardiac event

i.e. myocardial infarction, ECG evidence of past myocardial infarction or newly recognised left bundle branch block, angina, cardiac arrest, coronary artery bypass grafting, coronary angioplasty

Risk of recurrence, sudden loss of capability, exercise limitation

### Ischaemic cerebrovascular disease

(stroke or transient ischaemic attack)

Risk of recurrence, sudden loss of capability, mobility limitation. Risk of other circulatory disease causing sudden loss of capability.

Assess risk of future cardiac events

### Arterial - claudication

Risk of other circulatory disease causing sudden loss of capability. Limits to exercise capacity

Standards similar to Group2 DVLA standards

<https://www.gov.uk/government/publications/msn-1886-ilo-work-in-fishing-convention-medical-standards>

<https://www.gov.uk/government/publications/the-approved-doctors-manual>

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## Cardiovascular disease (CVD)

Disease of the **heart and blood vessels**

**atherosclerosis / thrombosis** (heart, kidneys and eyes)

### 1. Coronary heart disease (coronary vessels)

Angina

Acute coronary syndrome

Heart Failure

### 2. Strokes and TIAs (carotid, vertebral vessels)

### 3. Peripheral arterial disease (PAD)

All vascular sites, - carotid, vertebral, upper extremity, mesenteric, renal, and lower extremity vessels

usually refers to atherosclerotic disease in lower extremity vessels (claudication)

### 4. Aortic disease

All conditions affecting the aorta –

Aortic aneurysm – commonest aortic diseases

Aortic wall weakens and bulges outwards - aneurysms (>50% diameter)

Usually asymptomatic

But with increasing diameter - chance of rupture - life-threatening bleeding

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## Impact of Atherosclerotic Cardiovascular Disease

- Chronic disorder developing insidiously throughout life
- Symptomatic : advanced stage
- One of the main causes of death and disability world wide
- Leading cause of death in England and Wales ( 1/3 of all deaths)
- In 2010, **180,000** people died from CVD
  - ~ **80,000** : Coronary heart disease
  - ~ **49,000** : Strokes
- Of the **180,000** deaths, **46,000** in <75 years, 70% of those in men
- CVD Death rates peaked : 1970s and 1980s , more than halved since then
- ~ 50% reduction in 55–64 year age group c/f 20% reduction in 35–44 year age group
- Coronary artery disease (CAD) : cause of death in a large percentage
- but stroke, renal failure, and complications from severe ischaemia of the lower extremities also contribute to an adverse prognosis
- 10% of the general population, 20% of those above 70 years and 30% of diabetics over 50 have PAD

Cardiovascular disease: risk assessment and reduction, including lipid modification Clinical guideline Published: 18 July 2014  
nice.org.uk/guidance/cg181

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## Atherosclerotic vascular disease : systemic disease

- Atherosclerosis : frequently involves the entire vascular system
- Symptoms secondary to it in one organ system (brain, heart, peripheral vascular system, or kidneys) : often evidence of atherosclerosis in the arteries of other organ systems.
- Common aetiology : presence of disease at one site increases the frequency of symptomatic and asymptomatic disease at another.
- Degree of concordance between sites : methods of diagnosis and selected population
- In one study over 90% of patients with PAD had abnormal angiograms
- Reduction of Atherothrombosis for Continued Health (REACH) Registry : substantial percentage of patients with chronic CAD : associated cerebrovascular disease, lower extremity artery disease (LEAD) or both.
- Varying degrees of narrowing at each vascular site - range of severity of symptoms while many will remain asymptomatic throughout life
- Acute events : thrombosis and/or embolism and/or occlusion of major artery
- Need for a heightened awareness of the possibility of atherosclerotic disease occurring at sites other than the presenting one**
- Elderly : degree of overlap of CAD, cerebrovascular disease, and LEAD particularly

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## Peripheral Matters PAD and CAD : Two Sides of the Same Coin

Patients with PAD : higher risk of subclinical CAD , cardiovascular (CV) events  
>42% of CAD also have PAD

Severity of PAD correlates : development of and complications of CAD

Cardiovascular risk correlates to the severity of symptoms of PAD

**Asymptomatic individuals** : lowest risk

- arterial bruits linked with coronary heart disease

Peripheral manifestations - important prognostic clues : burden of CAD ; subsequent adverse CV events

**Symptomatic PAD** c/f with patients without PAD :

- 70 % increased risk of CV events
- 80 % increased risk of death

**Clinically significant PAD** (ankle-brachial index [ABI] <0.9) :

prevalence of MI - 2.5 X higher c/f with patients without PAD

**PAD hospitalizations** : potential marker of severity of PAD: linked to **worse outcomes**

Presence of PAD also predicts : more severe CAD , including left main CAD or complex CAD (high SYNTAX score)

In patients with, vs. those without Hx of acute coronary syndromes, cerebrovascular accident/TIA : PAD associated with worse outcomes and more extensive CAD

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### PAD and CAD : similar pathophysiological mechanisms: overlapping disease states

Basis for the relationship of PAD to CAD and CV events :  
 Clinical overlap, established atherosclerotic risk factors predicting development of PAD & CAD  
 male sex, age, diabetes, smoking, HT, hyperlipidemia and chronic kidney disease  
 Beyond traditional risk factors, 1<sup>st</sup> degree relatives of PAD patients : higher risk of subsequent PAD development and CV events (stroke, MI or need for cardiac, lower extremity or carotid revascularization)  
 Underscores a hereditary basis for atherosclerotic disease  
 Highlights the multifactorial contributors to disease formation  
 Presence of PAD : overall higher burden of atherosclerotic disease → an increased risk profile that includes CAD  
 PAD may independently drive adverse CV outcomes :  
 • Functional limitations in ambulation : preclude exercise or activity (cardioprotective)  
 • Known Abnormal peripheral vasodilation and paradoxical vasoconstriction in response to increased metabolic needs during stress  
 This failure of arterial vasodilation can lead to ↑ ed systemic afterload → impaired cardiac output & O<sub>2</sub> delivery  
 Postulated as contributory Mechanism : adverse CV outcomes associated with PAD.  
 Drivers of increased adverse cardiac events in PAD are likely a combination of overlapping direct and indirect causal factors related to the development of PAD and its hemodynamic sequelae

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### Stroke /TIA

Mortality from stroke : 10% - 30%  
 Survivors - high annual risk of recurrent ischaemic events and mortality from MI & stroke  
 Risks of recurrent stroke 4% - 15% within a year after incident stroke and 25% by 5 yrs  
 28-40% of patients undergoing carotid endarterectomy : significant concomitant CAD  
 • Data from the Framingham Heart Study, the ARIC (Atherosclerosis Risk in Communities) Study and the Greater Cincinnati/Northern Kentucky Stroke Study :  
 ~ 88% of all strokes are ischaemic  
 ~ 9% are intra-cerebral haemorrhages and 3% are subarachnoid haemorrhages.  
 • For the NOMASS population (a population based study of people older than 40 years of age who lived in Northern Manhattan, New York), cerebral infarction attributed to extra-cranial carotid and vertebral artery disease was defined as clinical stroke with evidence of infarction on brain imaging associated with more than 60% stenosis or occlusion of an extra-cranial carotid or vertebral artery documented by non invasive imaging or angiography  
 (ESVS (EUROPEAN SOCIETY FOR VASCULAR SURGEONS) GUIDELINES 2009: INVASIVE TREATMENT FOR CAROTID STENOSIS: INDICATIONS, TECHNIQUES)

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### Extra-cranial cerebrovascular disease : a marker of systemic atherosclerosis

Patho- biology of carotid and vertebral artery atherosclerosis : similar to atherosclerosis in other arteries

Extra-cranial Carotid or Vertebral atherosclerosis : frequent atherosclerosis elsewhere : aorta, coronary arteries and peripheral arteries  
 Mechanisms for plaque disruption in extra-cranial Carotid and Vertebral arteries : similar to that proposed for Coronary arteries

Extra-cranial cerebrovascular disease (ECVD) : increased risk of MI and death due to cardiac disease  
 many patients with carotid stenosis : > risk of death caused by MI than of stroke  
 Coronary atherosclerosis is prevalent in patients with fatal stroke more frequently in those with Carotid or Vertebral artery atherosclerosis

Guideline on the Management of Patients with Extra-cranial Carotid and Vertebral Artery Disease  
 Journal of the American College of Cardiology .2011 / 2012

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### Coexistence of carotid and coronary atherosclerotic disease

Study of 803 autopsies with history of neurological disease (JAACC 2011 / 2012)			
	stroke (n=341)	No stroke (n=462)	P
Coronary plaque	72%	27%	<0.001
>50% coronary stenosis	38%	10%	<0.001
Evidence of MI	41%	13%	<0.001

- 2/3 of the cases of MI found at autopsy had been clinically silent.
- Severity of coronary atherosclerosis was related to the severity of the ECVD
- Risk factors - ECVD (cigarette smoking, hyper-cholesterolaemia, DM and HT)  
 • same for atherosclerosis elsewhere  
 • although difference exist in the relative contribution in various vascular beds

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### Stroke : cardiac event rates OXVASC

Population –based study of all TIA and non-disabling strokes (first episode) in Oxfordshire  
 Looked at annual event rates (MI, MI and sudden cardiac death (SCD) )

Patients with no Hx of Coronary artery disease

Annual rate of MI, MI&SCD	Carotid stenosis
< 1%	<30%
~ 1%	30-49%
>2%	> 50%

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## Stroke and concomitant cardiac risk

Evidence suggests that ischaemic stroke subtype provides important information on concomitant cardiac risk, especially in 3 situations

- (1) significant symptomatic or asymptomatic carotid stenosis (higher risk),
- (2) small-vessel cause of stroke (lower risk), and
- (3) cardiac embolism as the suspected cause of stroke (very high risk). Because carotid artery evaluation is recommended for most TIA and stroke patients, this information should be available in the great majority of patients

AHA/ASA Scientific Statement : Coronary Risk Evaluation in Patients With Transient Ischemic Attack and Ischemic Stroke. Circulation. 2003;108:1278. © 2003 American Heart Association, Inc.

- DVLA Group2 standards, Stroke/TIA: Licensing (1 yr post event) may be subject to a satisfactory medical report, including results of exercise ECG testing  
All recurrent strokes: ETT  
Single episode of stroke/TIA: ETT if carotid artery stenosis >50% or significant enough to require intervention

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## Cardiac Risk assessment in Vascular disease

- **Known CAD/IHD** (Angina, Acute Coronary Syndromes(ACS), PCI and/or CABG, Heart failure (if CAD likely cause))

- **Stroke/TIA**: 2 main groups of individuals:  
Degree of stenosis significant to warrant intervention (symptomatic patients i.e. Stroke/TIA or asymptomatic patients with significant stenosis)  
Evidence suggests: high risk of having concomitant coronary artery disease

All patients with history of stroke/TIA with evidence of atherosclerosis in carotid artery

Evidence suggests: a documented stroke/TIA: high risk of a future coronary artery event, regardless whether they are a candidate for intervention or not

- **Known PVD**
- **Abdominal aortic Aneurysm**

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## Cardiac Risk assessment : Which Tests ?

Hierarchy of Investigation : DVLA Group2 Licence

1. Bruce Protocol ETT
2. Myocardial perfusion scan :  
Reversible ischaemia in not >10% of myocardium  
OR Stress Echo :  
Reversible ischaemia in not >1 myocardial segment

Left Ventricular Ejection fraction >40%

Coronary angiography, Cardiac MRI not commissioned but results will be considered if available.

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## ETT – DVLA Group 2

- **Exercise tolerance testing**
    1. The test must be on a treadmill or a bicycle  
(cycling for 10 minutes with 20 W per minute increments, to a total of 200 W)
    2. The patient should be able to complete 3 stages of the standard Bruce protocol or equivalent safely, while remaining free of signs of cardiovascular dysfunction :
      - angina pectoris
      - syncope
      - hypotension
      - sustained ventricular tachycardia.
- No electrocardiographic ST segment shift (usually of not more than 2 mm horizontal or down-sloping) that is interpreted by a cardiologist as **indicative of myocardial ischaemia**, either during exercise or the recovery period.

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## ETT

**Diagnostic & Prognostic** tool for assessment : suspected / known IHD

Non-invasive, economical, easily available

High negative predictive value : rules out myocardial ischemia with a high confidence

ESC and AHA/ACC guidelines first-line class I indicated test in suspected stable IHD (able to exercise & an interpretable (ECG))

For diagnostic purpose

Positive ETT : signs / symptoms of ischemia during stress, ST depression, angina

Negative ETT : no significant ST changes / symptom free

Non-diagnostic : failure to achieve 85% of the MPRH and the test was negative

Indeterminate : baseline LBBB, a paced rhythm, LVH with repolarization changes and/or is on digoxin therapy

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## ETT : Prognostic Tool

- Several large prospective cohort studies, conducted principally in middle-aged men, suggest that ETT can provide independent prognostic information about the risk for future coronary heart disease events (relative risk with abnormal exercise tolerance testing, 2.0 to 5.0)

Exercise Tolerance Testing To Screen for Coronary Heart Disease: A Systematic Review for the Technical Support for the U.S. Preventive Services Task Force  
Data Sources: The MEDLINE database from 1966 through February 2003, hand-searching of bibliographies, and expert input

- We studied 582 patients without known coronary artery disease (CAD) who were clinically referred for ETT and CTA within 6 months. Patients were followed for cardiovascular (CV) death, non-fatal myocardial infarction (MI), or late revascularization (>90 days), stratified by Duke Treadmill Score (DTS) and CAD severity (≥50% stenosis). Mean age was 54 ± 13 years (63% male). In median follow-up of 40 months

Prognostic value of coronary CTA vs. exercise treadmill testing: results from the Partners registry. [Eur Heart J Cardiovasc Imaging](#). 2015 Dec; 16(12): 1338-1346

- Conclusion
- In this study and other recent studies : **low-risk ETT** patients have an **excellent prognosis at 40 months** despite a common prevalence of non-obstructive and obstructive CAD

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### ETT : Prognostic Indicators

- **ST depression**(horizontal or downsloping)
  - most reliable indicator of exercise-induced ischaemia
  - Diagnostic and prognostic marker
  - Asymptomatic ST depression post MI > 10-fold ↑ in mortality c/f normal ETT
- Ischemic ST changes during recovery from treadmill exercise in apparently healthy individuals has adverse prognostic significance similar to those appearing during exercise
- Resting ST-segment depression : a marker for adverse cardiac events in patients with and without known CAD
- Diagnostic end points of 2 mm of additional exercise-induced ST-segment depression or downsloping depression of 1 mm or more in recovery : useful markers in these patients for diagnosis of any coronary disease (likelihood ratio 3.4, sensitivity 67 percent, specificity 80 percent)

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### ETT : Other prognostic indicators

- **Exercise duration**
  - minutes and metabolic equivalents (METs)\*
  - most strongly associated with risk of coronary events and death, independent of age, sex, or known presence and severity of coronary artery disease
- **Exercise hypotension**
- **Chronotropic incompetence**
- **Heart rate recovery**
- **Ventricular ectopy**

\* one MET is defined as 3.5 mL O<sub>2</sub> uptake/kg per min, which is the resting oxygen uptake in a sitting position  
 • Less than 5 METS is poor, 5-8 METS is fair, 9-11 METS is good, and 12 METS or more is excellent

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### Exercise duration : Strongest Prognostic variable

- Inability to exercise >6 minutes(Brucue protocol ) or inability to ↑ HR to >85% of maximum predicted heart rate (MPHR) : Significant indicators of ↑ risk of coronary events , 5-year survival 50% - 72%
- Reaching stage 3 of a modified Bruce protocol with a BP response >30 mm Hg : Annual mortality of <2%
- Achievement >10 METS : 5-year survival of 95% : (even in the presence of known CAD)
- The Coronary Artery Surgery Study (CASS): analyzed 30 variables in 4,083 patients (symptomatic CAD ) in patients with 3 vessel coronary disease , preserved left ventricular function who had good exercise capacity, **12 minutes or > : Survival at 4 years was 100%**

Ability to achieve a 9-minute-high exercise capacity (≥10 METS) : overall MACE of 0.4% per year predictor of favourable prognosis

Yao SS, Agarwal V, Chauthry FA. Prognostic value of treadmill stress echocardiography at extremes of exercise performance: submaximal <85% maximum predicted heart rate versus high exercise capacity ≥10 metabolic equivalents. Echocardiography 2014;31:340-6.

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### EXERCISE HEMODYNAMICS MILLER

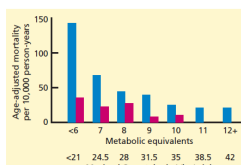


FIGURE 1. Age-adjusted, all-cause mortality rates per 10,000 person-years of follow-up by physical fitness categories in 3,120 women and 10,224 men in the Aerobics Center Longitudinal Study.

BLAIR SN, KOHL HW 3RD, RAFFENBERGER RS JR, CLARK DG, COOPER KH, GIBBONS LW. PHYSICAL FITNESS AND ALL-CAUSE MORTALITY: A PROSPECTIVE STUDY OF HEALTHY MEN AND WOMEN. JAMA 1989; 262:2395-2401. COPYRIGHT © 1989, AMERICAN MEDICAL ASSOCIATION. ALL RIGHTS RESERVED.

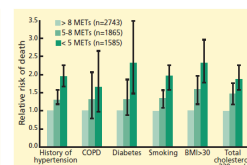


FIGURE 2. Relative risks of death from any cause among subjects with various risk factors who achieved an exercise capacity of less than 5 metabolic equivalents (METs) or 5 to 8 METs, as compared with subjects whose exercise capacity was more than 8 METs. Error bars are 95% confidence intervals for the relative risks. BMI = body mass index; COPD = chronic obstructive pulmonary disease.

MYERS L, PRAKASH M, FROELICHER V, DO D, PARTINGTON S, ATWOOD JE. EXERCISE CAPACITY AND MORTALITY AMONG MEN REFERRED FOR EXERCISE TESTING. IN ENGL J MED 2002; 346:793-801. COPYRIGHT © 2002, MASSACHUSETTS MEDICAL SOCIETY. ALL RIGHTS RESERVED.

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### Exercise Hypotension

- SBP lower during exercise than while standing at rest before exercise
- failure of cardiac output to increase during exercise.
- associated with severe coronary disease and left Ventricular dysfunctions
- Dubach et al, in a study of 2,036 patients who underwent exercise treadmill testing to evaluate chronic coronary artery disease found that exercise hypotension : 3 fold higher risk of cardiac events over 2 years
- In a large meta-analysis of exercise testing following myocardial infarction, the only independent predictors of risk were limited exercise workload and exercise hypotension

Froelicher VF, Parulek S, Pawan W, Risch M. Application of metaanalysis using an electronic spread sheet to exercise testing in patients after myocardial infarction. Am J Med 1987; 83:1045-1054

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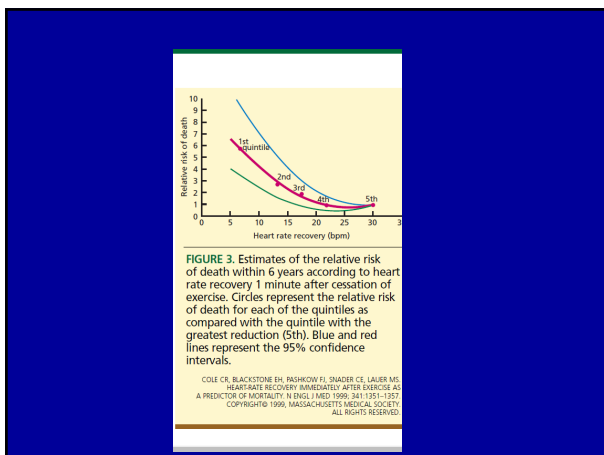
### Chronotropic incompetence & Heart Rate Recovery

- HR should reach or > 85% of Maximum Predicted HR (220- age)
- **Chronotropic Incompetence** : Failure to achieve target HR predicts all cause and cardiovascular death
- occasionally associated with ↑ed mortality and cardiac events even after adjusting for LV function and the severity of exercise-induced myocardial ischemia

**HR recovery** : Abnormal HR recovery : bad prognosis  
 6-yr mortality 2-3 times > c/f normal recovery HR

HR should ↓ by at least 12 beats in the 1st minute of recovery, which is mediated through vagal reactivation. Otherwise, recovery is considered abnormal

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### Ventricular Ectopy

Sustained VT or VF due to CAD or LV dysfunction : life threatening

**Short ventricular ectopies**  
A review : ventricular ectopy during exercise testing or recovery :

- increased death rate in 13 out of 22 studies. 15 of these studies included patient populations with symptomatic or known coronary artery disease; the other 7 studies were in healthy people without symptoms

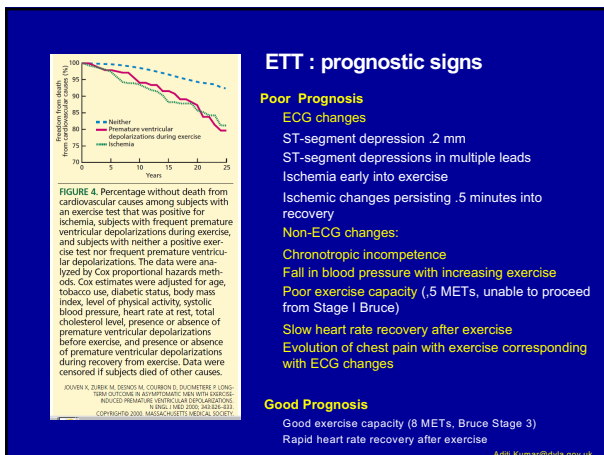
Frolikis et al41 evaluated 29,244 patients referred to Cleveland Clinic for exercise treadmill testing .After adjusting for confounding variables, only frequent ventricular ectopy in recovery, but not during exercise, was associated with an increased death rate (adjusted hazard ratio 1.5; 95% CI 1.1–1.9; P = .003).

Jouven et al40 Having frequent premature ventricular contractions was associated with a higher risk (RR = 2.67) of cardiovascular death over 23 years of followup, independent of ischemia (FIGURE 4)

The associations between exercise induced ventricular ectopy and ischemia and left ventricular function are unclear

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The exercise treadmill test: Estimating cardiovascular prognosis :  
**TODD D. MILLER, MD\***  
Professor of Medicine, Co-Director, Nuclear Cardiology Laboratory, Department of Cardiovascular Diseases, Mayo Clinic, Rochester, MN

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Lauer MS, Okin PM, Larson MG, Evans JC, Levy D. Impaired heart rate response to graded exercise. Prognostic implications of chronotropic incompetence in the Framingham Heart Study.

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### MPS : predicting future coronary events

- Demonstrated in a large number of high-quality studies and in thousands of patients.
- Extent and severity of inducible ischaemia : most important variables that predict the likelihood of future events
- (others : ↑lung uptake of thallium , stress-induced ventricular dilatation, LVEF )
- Markers of LV dysfunction : predict cardiac mortality
- Inducible ischaemia predicts acute coronary syndromes
- MPS ; Incremental prognostic value even after clinical assessment, exercise ECG and coronary angiography
- Abnormal MPS : on average an annual event rate (cardiac death or MI ) : 6.7% (Table 3)
- Normal MPS (universal finding) : good clinical outcome, irrespective of other features e.g. non-obstructive CAD
- 16 studies performed between 1994 and 2001, which reported 20,983 patients with normal MPS and a mean follow-up of 28 months, showed a rate of cardiac death or myocardial infarction of 0.7% per year, a rate similar to that of an asymptomatic population (Table 3). Similar findings have recently been reported in a multicentre registry of 4,728 patients .

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**Table 6**  
Prognostic value of MPS in definite or suspected CHD (adapted from reference [11])

Year	Author [ref.]	No.	Agent	Abnormal MPS (%)	Mean FU (m)	HE (%)	HE with abnormal MPS (%)	HE with normal MPS (%)	RR
2001	Gabata [113]	459	Tl-201	77	37	2.5	3.0	0.9	3.25
1999	Vassallo [114]	1,137	201Tl	66	72	1.5	2.0	0.6	3.53
1998	Hachisuroh [108]	5,183	MIBI/201Tl	43	21.4	3.0	5.9	0.8	7.50
1998	Olsson [112]	225	201Tl	49	44.4	1.8	2.7	0.9	2.86
1998	Abraham [116]	1,086	MIBI	62	27.6	3.4	5.0	0.6	3.92
1997	Snader [117]	3,400	201Tl	21	-24	1.6	-3.8	ACM <sup>a</sup> -1 (ACM <sup>b</sup> )	3.75
1997	Boyer [118]	229	MIBI	32	19.2	2.2	5.1	0.8	6.23
1997	Onigian [119]	392	MIBI	67	22	6.0	8.7	0.8	10.67
1995	Heller [120]	512	MIBI	58	12.8	4.6	6.9	1.3	5.29
1994	MacIntyre [121]	1,926	201Tl	63	33	2.0	2.9	0.5	6.23
1994	Kanai [122]	177	201Tl	83	22	4.3	5.2	0	-
1994	Stratmann [123]	534	MIBI	66	13	10.1	14.3	1.6	9.12
1994	Stratmann [124]	521	MIBI	60	13	4.2	6.7	0.5	14.60

ACM, AR-cause mortality; HE, hard event (cardiac death or non-fatal MI); RR, relative risk; other abbreviations as defined in Table 1 and list of abbreviations

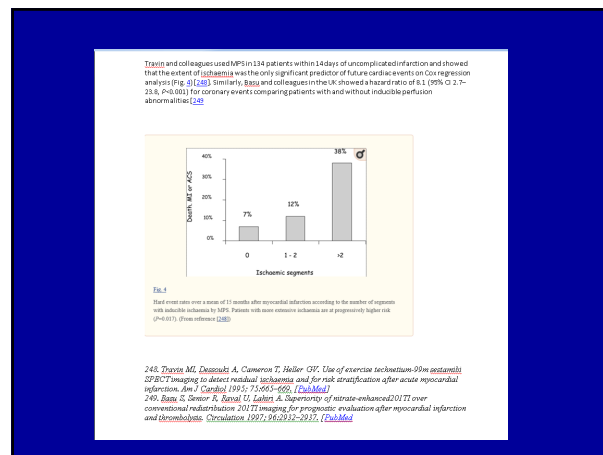
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**Table 7**  
Prognostic value of normal MPS in patients presenting with stable chest pain (adapted from reference [133])

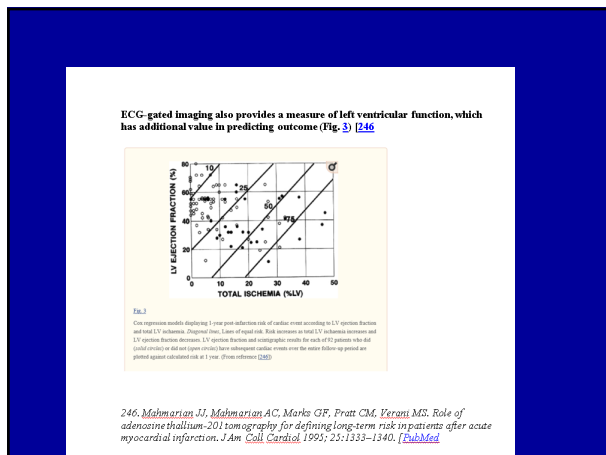
Year	Author [ref.]	No.	Agent	Normal MPS (%)	Mean FU (months)	HF with normal MPS (% per yr)
2001	Gabain [113]	459	Tetro	23	37	0.9
2000	Chouzas [114]	236	Tetro <sup>200</sup> TI	100	25	0.4
1999	Gilvassat [115]	4,473	200TI/MBI	100	26	0.6
1999	Szeman [122]	473	MBI	100	30	0.2
1999	Yamamoto [114]	1,137	200TI	34	72	0.6
1998	Hashimoto [116]	5,183	MBI <sup>200</sup> TI	57	21.4	0.8
1998	Olivot [115]	225	200TI	51	44.4	0.9
1998	Alkayhan [116]	1,086	MBI	38	27.6	0.6
1997	Smolke [117]	2,400	200TI	79	-24	-1.0 (ACM)
1997	Boyce [118]	229	MBI	68	19.2	0.8
1997	Chelvanse [119]	392	MBI	33	22	0.8
1995	Heller [120]	512	MBI	42	12.8	1.3
1994	Macherson [121]	1,926	200TI	37	33	0.5
1994	Tamari [122]	177	200TI	17	22	0
1994	Stammann [123]	234	MBI	24	13	1.6
1994	Strassman [124]	521	MBI	40	13	0.5
Total		20,963		53	28.3	0.7

ACM, All-cause mortality; HF, hard event (cardiac death or non-fatal MI); FU, relative risk; other abbreviations as defined in Table 1 and list of abbreviations

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### Stress echo and prognosis

- Strong tool in the diagnosis and risk stratification of patients who have CAD or are suspected of having the disease
- ability to add incremental and independent information to results of ETT
- provides structural and functional data

Hallmark of myocardial ischemia : occurrence of reduced systolic wall thickening due to the increased myocardial oxygen demand and supply-demand mismatch

	Normal test	vs	Abnormal test
Annual event rates			
Cardiac death	0.6%		2.8%
All cardiac events	3.3%		6.9% (P < 0.0001)

- Large form prognostic value of Dobutamine stress Echocardiography compared with myocardial perfusion
- July 2004 - The American Journal of Medicine *Am J Med* Schirmer, James J, Box, John, Elbers, Van Erckmann

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### Stress echo and prognosis

- a study by Marwick *et al.* [2001] : exercise ECHO was used ,data on 5,375 patients collected , followed up for 6 years.  
Normal echocardiography : mortality of 1% per year
- In the study by McCully *et al.* [1998] exercise ECHO on 1,325 patients
- median length of FU : 23 months
- 33 cardiac events in 26 patients and 3 patients died of cardiac causes which were 14, 19 and 20 months after the exercise ECHO
- 10 patients : nonfatal MIs and 20 underwent catheterization
- Survival rates free of cardiac death or nonfatal MI at 1, 2 and 3 years were 99.5%, 98.8% and 98.6%.
- The calculated cardiac death and nonfatal MI rate per person-year : 0.5%
- The cardiac event rate per person : 0.9%
- LVEF : best prognostic indicator of mortality risk from a sudden event,
- Increase mortality risk with LVEF < 40%

*LVEF Heart Failure - Review Article, Jessop M, Brozina S N Engl J Med* 2003;148:2007-18

Echocardiography can be vital in the risk stratification of the population of individuals who are at intermediate level of risk based on the Duke score and a non-diagnostic ETT.

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### Summary

**Atherosclerosis : Systemic disease**  
symptoms secondary to atherosclerosis in one organ system ( brain, heart, peripheral vascular system, or kidneys ) : often evidence of disease in the arteries of other organ systems.

**Peripheral Arterial ,Cerebrovascular & Coronary artery disease**  
**Strong Correlation**

**Presence of PAD in one territory**  
Investigation for occlusive atherosclerotic disease elsewhere

Functional Cardiac tests ETT , MPS , Stress ECHO : abnormal tests strong predictors of future coronary /cardiac events

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## Is your patient FIT for Sea ?

- What is the risk of the individual suffering a sudden and disabling event ?
- Is the person able to carry out duties safely at sea at all times?
- The dictionary defines accident as "an unexpected and undesirable event, a mishap unforeseen and without apparent cause." Strictly speaking, most accidents are not accidents at all: they are collisions that could and should have been avoided. So, what causes them, and how can you avoid them?

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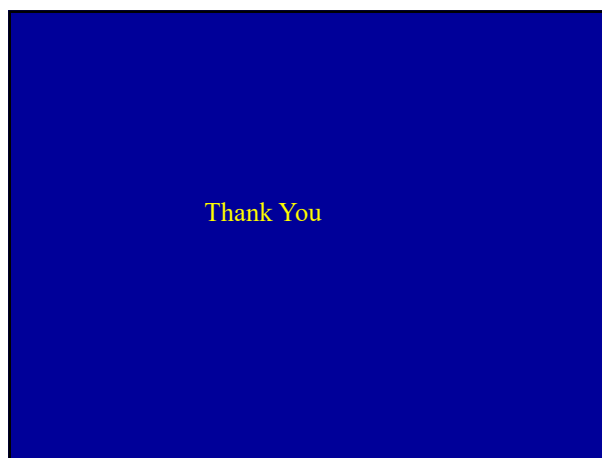
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QUESTIONS?

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