

ease are 81% and 66%, and for 3-vessel or left main coronary disease, 86% and 53%, respectively (40).

Weiner et al (32) studied 4083 medically treated patients in CASS and identified a high-risk patient subset (12% of the population) with an annual mortality rate greater than or equal to 5% per year when the exercise workload was less than Bruce stage I and the exercise ECG showed ST-segment depression greater than or equal to 1 mm. A low-risk subset (34% of the population) who were able to complete or do more than Bruce stage III with a normal exercise ECG had an annual mortality rate of less than 1% per year over 4 years of follow-up (32). Similar results have been reported by others (41,42).

*a. Summary of Evidence*

Table 6 lists publications in which exercise test results and perioperative events were reported. In most series, very-high-risk patients (recent MI, unstable angina, HF, and serious ventricular arrhythmias) were excluded. McPhail et al (113) reported on preoperative exercise treadmill testing and supplemental arm ergometry in 100 patients undergoing surgery for peripheral vascular disease or abdominal aortic aneurysm. Of the 100 patients, 30 were able to reach 85% of age-predicted heart rate maximum, and only 2 had cardiac complications (6%). In contrast, 70% of the population were unable to reach 85% of age-predicted heart rate or had an abnormal exercise ECG. In this group the cardiac complication rate (MI, death, HF, or ventricular arrhythmia) was 24% (17 patients).

The data in Table 6 indicate a peak exercise heart rate greater than 75% of age-predicted maximum can be expected in approximately half of patients who undergo treadmill exercise, with supplemental arm ergometry when necessary for patients limited by claudication (107). The frequency of an abnormal exercise ECG response is dependent on prior clinical history (107,110). Among patients without a cardiac history and with a normal resting ECG, approximately 20% to 50% will have an abnormal exercise ECG. The frequency is greater (35% to 50%) in patients with a prior history of MI or an abnormal rest ECG. The risk of perioperative cardiac events and long-term risk is significantly increased in patients with an abnormal exercise ECG at low workloads (107,108,113).

In contrast to the above studies of patients with vascular disease, in a general population of patients of whom only 20% to 35% had peripheral vascular disease and were undergoing noncardiac surgery, Carliner et al (114) reported exercise-induced ST-segment depression greater than or equal to 1 mm in 16% of 200 patients older than 40 years (mean age, 59 years) being considered for elective surgery. Only 2 patients (1%) had a markedly abnormal (ST-segment depression of 2 mm or more) exercise test. Of the 32 patients with an abnormal exercise test, 5 (16%) died or had a nonfatal MI. Of 168 patients with a negative test, 157 (93%) did not die or have an MI. In this series, however, the results of preoperative exercise testing were not statistically significant independent predictors of cardiac risk.

Table 5 provides a prognostic gradient of ischemic responses during an ECG-monitored exercise test as developed for a

**Table 6.** Preoperative Exercise Testing Before Major Noncardiac Surgery

Author	n	Abnormal Test (%)	Criteria For Abnormal Test	Events	Patients With Predictive Value		Event	Comments
					Positive Test	Negative Test		
<b>Peripheral vascular surgery or abdominal aortic aneurysm repair</b>								
McCabe 1981 (106)	314	36	STD, CP, or A	38% (15/39)	81% (13/16)	91% (21/23)	D,M,I,H,A	
Cutler 1981 (107)	130	39	STD	7% (9/130)	16% (8/50)	99% (79/80)	D,M	Less than 75% MPHR increased risk
Arous 1984 (108)	808	17	STD	NR	21% (19/89)	NR	D,M	
Gardine 1985 (109)	86	48	STD	11% (2/19)	11% (1/9)	90% (9/10)	D,M	
von Knorring 1986 (110)	105	25	STD, A, or CP	3% (3/105)	8% (2/26)	99% (78/79)	D,M	
Kopecky 1986 (116)	114	57	Less than 400 kpm	7% (8/110)	13% (8/63)	100% (47/47)	D,M	
Leppo* 1987 (111)	60	28	STD	12% (7/60)	25% (3/12)	92% (44/48)	D,M	Exercise test results used to refer patients for revascularization
Hanson 1988 (112)	74	57	STD	3% (1/37)	5% (1/19)	100% (18/18)	D,M	Arm ergometry
McPhail* 1988 (113)	100	70	Less than 85% MPHR	19% (19/100)	24% (17/70)	93% (28/30)	D,M,A,F	Less than 85% MPHR; p=0.04; STD; NS
Urbinati 1994 (117)	121	23	STD	0	0/28	100% (93/93)	D,M	Carotid endarterectomy patients. STD predicted late death.
<b>Peripheral vascular surgery or major noncardiac surgery</b>								
Carliner 1985 (114)	200	16	STD	32% (16/200)	16% (5/32)	93% (157/168)	D,M	5 METs (NS)

A indicates cardiac arrhythmia; CP, chest pain; D, death; F, failure; H, hypotension; I, myocardial ischemia; M, myocardial infarction; MET, metabolic equivalent; MPHR, maximum predicted heart rate; NR, not reported; NS, not significant; STD, exercise-induced electrocardiographic ischemia.

\*Studies with prospective collection of postoperative electrocardiogram and cardiac enzymes.

In references 106, 108, 109, 112, and 116, the total number of patients undergoing peripheral vascular surgery was less than the total number tested.