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Coronary Angiography Outcomes of U. S. Army Aircrew with the Finding of Coronary Artery Calcifications: Aviation Epidemiology Data Register

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U.S. Army aircrew with a history of coronary artery calcification were identified by cardiac fluoroscopy, followed by coronary angiography, in the U.S. Army Aviation Epidemiology Data Registry for the period 1 January 1988 to 1 August 1992. Eighty-two aircrew met these criteria. Their angiography outcomes are summarized. The positive predictive value of cardiac calcifications for predicting any degree of coronary artery occlusion was 82.9%. The Framingham Risk Index, total serum cholesterol, cholesterol/HDL-cholesterol ratio, and results of the graded exercise treadmill test and thallium scan were not significant factors in predicting the angiography outcome when coronary artery calcifications were present. Aircrew in coronary artery disease screening programs should be examined for coronary artery calcifications by cardiac fluoroscopy and referred for coronary angiography if calcifications are seen.

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Introduction

In 1988, the U.S. Army Aeromedical Center (USAAMC), Fort Rucker, Alabama, directed the screening of selected aircrew members for coronary artery calcifications by image-intensified cardiac fluoroscopy as part of a major revision of the Army Aeromedical Cardiovascular Disease Screening Program (Department of the Army, 1988; Department of the Army, 1991a; Department of the Army, 1991b). The decision to add cardiac fluoroscopy to the cardiovascular-vascular disease screening program was based on literature review, and then unpublished experience of the Aeromedical Consultation Service, Brooks Air Force Base (Loecker et al., 1992). This report summarizes the coronary angiography outcomes of 82 asymptomatic U.S. Army aircrew members with coronary artery calcifications by cardiac fluoroscopy.

Background

Cardiac fluoroscopy is one of the oldest tests used for the diagnosis of coronary artery disease. Today, its use in clinical medicine is limited by the introduction of other diagnostic techniques. There is a general lack of knowledge concerning the technique, interpretation, and value of cardiac fluoroscopy (Green and Kelly, 1980; Kelley and Newell, 1983; Uretsky et al., 1988).

There is a strong association between the finding of coronary artery calcifications and coronary artery atherosclerosis in populations with signs and symptoms of coronary artery disease (Lieber and Jorgens, 1961; Hamby et al., 1974; Bartel et al., 1974; Johnson, Laiken, and Shabetai, 1978; Margolis et al., 1980; Chaitman et al., 1984; Huang et al., 1985; Uretsky et al., 1988; Bobbio et al., 1988; Schultz et al., 1989). This association has been documented in some asymptomatic populations, such as office workers (Kelley, Huang, and Langou, 1978; Aldrich et al., 1979), U.S. Army soldiers (Wortham et al., 1990), and U.S. Air Force aircrew members (Loecker et al., 1992). A related technical report discusses the history, technique, outcomes, and controversies in using cardiac fluoroscopy in asymptomatic and symptomatic patients (Mason, 1993).

From 1988 to 1992, about 1,841 asymptomatic U.S. Army aircrew members, who were age 40 and older with elevated cardiac risk factors, entered a stratified cardiovascular disease screening program and underwent cardiac fluoroscopy. One in 18 had coronary artery calcifications by cardiac fluoroscopy and were referred for tertiary aeromedical cardiology consultation. Appendix A outlines the relationship of cardiac fluoroscopy and coronary angiography in the U.S. Army Aeromedical Cardiovascular Disease Screening Program (Department of the Army, 1991a).

The U.S. Army Aviation Epidemiology Data Register (AEDR) is a family of related databases storing demographic and medical findings of U.S. Army aircrew members. One component, the Waiver and Suspense File (WSF), is a computerized database of major health findings that indexes a Microx® image library containing the details of each case. The event and general outcomes of cardiac fluoroscopy and catheterization are entered into the WSF. The test reports are stored in the image library.

Methods

The WSF component of the AEDR was searched for all files with abnormal cardiac fluoroscopy for the period of 1 January 1988 to 1 August 1992. The image library file and AEDR summary sheet for each case were reviewed for the data elements outlined in the basic data presentation in Appendix B.

The identified aircrew members were asymptomatic U.S. Army aviators who were found during routine physical examination to have failed level 1 of the U.S. Army Aeromedical Cardiovascular Disease Screening Program as defined by assessment of coronary artery disease risk factors in Appendix A. The Framingham Risk Index (Gordon, Sorlie, and Kannel, 1971) was calculated by the AEDR software using the multiple logistic regression model found in Appendix C.

The cardiac fluoroscopy examinations generally were conducted by radiologists and cardiologists in military medical treatment facilities. The cardiac fluoroscopy report was considered abnormal if any degree of calcification was seen moving synchronously with the heart shadow in a location consistent with coronary artery anatomy by multiple views. For this study, the authors relied upon written radiologic reports only and did not interpret plain spot films, cardiac fluoroscopy video tapes, or cinefluorograms.

The graded exercise treadmill tests (GXTs) generally were conducted by primary care physicians in military medical treatment facilities. Two of the authors (Kevin Mason, Fort Rucker, Alabama, and Paul Celio, Brooks Air Force Base, Texas) reviewed the GXT tracings from baseline to 5 minutes after peak exercise. The GXTs were considered aeromedically abnormal if there was 1.0 millimeter or more of ST segment depression from the hyperventilation baseline in any three consecutive heart beats in any lead at any time during the test.

All coronary angiography cinegrams were interpreted by the aeromedical cardiology consultant team at the Armstrong Laboratory, Brooks Air Force Base, Texas. They determined the degree of coronary artery occlusion from 0 to 100 percent. Normal coronary arteries were defined as having no degree of occlusion

or intimal roughening only. Minimal coronary artery disease was defined as any coronary artery occlusion that did not exceed 30 percent occlusion. If there were multiple occlusions, each not exceeding 30 percent, the sum total of the occlusions could not exceed 100 percent. For example, one 20 percent occlusion in the circumflex coronary artery and two 30 percent occlusions in the right coronary artery resulted in a total of 80 percent, meeting the minimal coronary artery disease criteria. Aeromedically significant coronary artery disease was defined as any occlusion(s) exceeding the minimal coronary artery disease criteria.

Univariate analyses were derived using Statistical Analysis Systems LOGIST program (SAS® Institute, Incorporated, 1991). Multivariate analysis was not used in these models to control for variables, such as age, due to the small sample size.

Results

One hundred aircrew members were identified by the AEDR search with a history of coronary artery calcifications by cardiac fluoroscopy for the period of 1 January 1988 to 1 August 1992. Ten aircrew members were dropped from the study when they declined further evaluation and did not return to flying duties. Seven other aircrew members had recurrent supraventricular tachycardia by Holter monitor and one additional aircrew member had concentric left ventricular hypertrophy by echocardiogram. They were excluded from the study since these findings resulted in medical termination from aviation service without referral for occupational coronary angiography. The remaining 82 aircrew members underwent diagnostic left heart catheterization with coronary angiography and left ventriculography.

Appendix D contains descriptive summary tables of age, total cholesterol, HDL-cholesterol, and Framingham Risk Index for the 82 aircrew members undergoing coronary angiography.

Of the 82 aircrew members undergoing coronary angiography, 14 had normal coronary arteries or intimal roughening only, 30 met the criteria for minimal coronary artery disease, and 38 met the criteria for aeromedically significant coronary artery disease. The positive predictive values of coronary artery calcifications by image-intensified cardiac fluoroscopy stratified by selected degrees of coronary artery disease are summarized in Table 1.

Table 1.

Positive predictive value of abnormal cardiac fluoroscopy based on coronary angiography outcome.

Degree of coronary artery occlusion	N=	Positive predictive value
By any degree of occlusion	68	82.9%
By aeromedically significant criteria, any occlusion >30%	38	46.3%
By clinical criteria, any occlusion ≥50%	34	41.5%

The findings were evaluated by univariate logistic regression analysis. The degree of coronary artery disease by coronary angiography was the dependent variable. The Framingham Risk Index, total serum cholesterol, a ratio of the total serum cholesterol over the HDL cholesterol, graded exercise treadmill test, and thallium scan were tested as independent variables. Tables 2 and 3 summarize these findings.

For the aircrew members with abnormal cardiac fluoroscopy, only the Framingham Risk Index greater than 7.49 was significantly related to the finding of any degree of coronary artery disease by angiography (minimal or aeromedically significant criteria) of those variables listed in Table 2. The degree of significance was borderline for the Framingham Risk Index greater than 7.49 percent (Odds ratio (OR)=8.56 with a 95 percent confidence interval (C.I.) of 1.06, 69.3), with the wide C.I. due to the small sample size.

For the aircrew members with abnormal cardiac fluoroscopy, only the finding of abnormal thallium was significantly related to the finding of aeromedically significant coronary artery disease only by angiography as listed in Table 3. The degree of significance was borderline (OR=3.61, 95 percent C.I.= 1.19, 10.9) for the finding of abnormal thallium, with the wide C.I. due to the small sample size (N=82).

Table 2.

Univariate logistic regression analyses using the finding of minimal or significant coronary artery disease by angiography.

Independent variables	Odds ratio*	95% C.I.*
Framingham Risk Index ≥ 7.5%	8.56	(1.06,69.3)**
Framingham Risk Index ≥ 5.0%	2.44	(0.736,8.07)
Abnormal thallium scan	2.08	(0.417,10.4)
Total cholesterol ≥ 240 mg/dl	1.12	(0.350,3.57)
Cholesterol/HDL ratio ≥ 6.0	0.83	(0.245,2.83)
Abnormal graded exercise treadmill	0.31	(0.079,1.20)

* Based on maximum likelihood estimates from SAS® LOGIST.
** Borderline significance (p=0.0442).

Table 3.

Univariate logistic regression analyses using the finding of significant coronary artery disease by angiography.

Independent variable	Odds ratio*	95% C.I.*
Abnormal thallium scan	3.61	(1.19,10.9)**
Framingham Risk Index ≥ 7.5%	1.94	(0.769,4.89)
Abnormal graded exercise treadmill	1.92	(0.787,4.70)
Framingham Risk Index ≥ 5.0%	1.75	(0.640,4.78)
Cholesterol/HDL ratio ≥ 6.0	0.69	(0.277,1.73)
Total cholesterol ≥ 240 mg/dl	0.65	(0.271,1.57)

* Based on maximum likelihood estimates from SAS® LOGIST.
** Borderline significance (p=0.0232).

From another perspective, the records of 157 aircrew members with an abnormal cardiac fluoroscopy, an abnormal graded exercise treadmill test, or both, who completed coronary angiography for the period 1988 through 1992, were examined. Of the 49 aircrew members found to have aeromedically significant coronary artery disease, 38 (77.5 percent) had an abnormal cardiac fluoroscopy. An abnormal cardiac fluoroscopy was the only abnormal test resulting in referral for coronary angiography for 36 of 157 (22.9 percent). Thirteen cases of asymptomatic, aeromedically significant coronary artery disease were found in this subgroup of 36. Twenty of the 36 had minimal coronary artery disease.

Only 3 of the 36 had normal coronary arteries by coronary angiography.

Discussion

This study reports the coronary angiography findings of 82 asymptomatic U.S. Army aircrew members with coronary artery calcifications by cardiac fluoroscopy in a worldwide, operational cardiovascular disease screening program. They were stratified into low and high risk groups for coronary artery disease in primary screening by analysis of their Framingham Risk Index and cholesterol profile. Those 40 years of age and older who were found to be at high risk for developing coronary artery disease were referred for secondary screening that included image-intensified cardiac fluoroscopy and graded exercise treadmill testing. Regardless of the results of the graded exercise treadmill test, those with coronary artery calcifications by cardiac fluoroscopy were referred for occupational coronary angiography by left heart catheterization. In this asymptomatic population, there was a strong association between the finding of coronary artery calcifications by cardiac fluoroscopy and the finding of anatomic coronary artery disease by coronary angiography with a positive predictive value of 82.9 percent.

When the cardiac fluoroscopy demonstrated coronary artery calcifications, the results of other noninvasive screening tests could not reliably predict the coronary angiography outcome. Because of this observation, the secondary screening method in the U.S. Army Aeromedical Cardiovascular Disease Screening Program could be modified. Those failing primary coronary artery disease screening could be referred first for image-intensified cardiac fluoroscopy. If coronary artery calcifications are seen, the aircrew member could be referred directly for tertiary aeromedical cardiology consultation in levels three and four of the program. If no coronary artery calcifications are found, the aircrew member then could complete secondary screening by undergoing graded exercise treadmill test.

The stratified cardiovascular disease screening approach used in this study was developed for a specific occupational population, U.S. Army aircrew members. The first signs and symptoms of coronary artery disease are often dramatic and incapacitating, such as severe chest pain and sudden death. The U.S. Army is pursuing the diagnosis of aeromedically significant coronary artery disease in asymptomatic aircrew members at risk for disease in the interest of military operational readiness, public safety,, and tort liability reduction. Therefore, the methods and observations of this study may be applicable only to aircrew populations flying military aircraft, or perhaps, other special occupations where a high degree of physical readiness is

required for public safety, such as firemen and search/rescue technicians.

Conclusions

The finding of coronary artery calcifications by image-intensified cardiac fluoroscopy reliably predicts the finding of coronary artery disease by coronary angiography in middle-aged, asymptomatic U.S. Army aircrew members found to be at higher risk for disease by screening their Framingham Risk Index and cholesterol profile. This association is so strong that other non-invasive coronary artery disease screening tests, such as graded exercise treadmill test and thallium scan, fail to reliably predict the coronary angiography outcome in this select population. Cardiac fluoroscopy has proven to be a valuable addition to the U.S. Army Cardiovascular Disease Screening Program for asymptomatic aircrew members.

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Appendix A.

U.S. Army Aeromedical Cardiovascular Disease Screening Program: principles and guidelines.

Army Aeromedical Cardiovascular Disease Screening Program

General principle

The principle of the Army Aeromedical Cardiovascular Disease Screening Program (AACVDSP) is multiple level stratification of aircrew members based on risk assessment and test findings. First, Army aircrew members are stratified into low and high risk groups for the likelihood of developing cardiovascular disease by assessment of risk factors using history and physical findings. Only aircrew members found to be at high risk in the primary screening are referred for the second level of noninvasive screening tests (Department of the Army, 1988; Department of the Army, 1991a). The intent is to use Bayesian theory and enhance the predictive value of the second level screening tests by applying the tests only to a population with a theoretical higher prevalence of underlying disease (Hickman, 1987).

Level 1

Level 1 is the primary level of stratification for screening. Aircrew members are asked questions relating to their cardiovascular system history, to include smoking history. They undergo a resting electrocardiogram (EKG), which is compared to previous tracings. Serum lipids are evaluated, with total cholesterol (T-CHOL) and high density lipoprotein cholesterol (HDL-CHOL) required as a minimum. Their Framingham Risk Index is calculated.

Aircrew members with signs and symptoms of cardiovascular disease, such as exertional chest pressure or serial EKG changes, are considered as screening program failures. They are referred for clinical care and evaluation as symptomatic patients.

Asymptomatic aircrew members are divided into low and high risk groups for the likelihood of developing cardiovascular disease by assessment of risk factors. High risk aircrew members are those who are age 40 years and older, and who have a Framingham Risk Index of five percent or greater, or a serum T-CHOL 270 mg/dl or greater, or a ratio of the serum T-CHOL over the serum HDL-CHOL of 6.0, or greater. High risk aircrew members are referred for secondary level of screening in level 2.

Level 2

Asymptomatic aircrew members at high risk by level 1 screening are referred for secondary screening. Secondary screening tests are graded exercise treadmill test and cardiac fluoroscopy. The graded exercise treadmill test is abnormal if there is greater than or equal to 1.0 mm ST segment depression in

any of 12 leads in any 3 consecutive heart beats at any time during the test. Certain exercise-induced electrocardiographic arrhythmias, such as ventricular or supraventricular tachycardia, or left bundle branch block, also are abnormal findings (Department of the Army, 1989). The cardiac fluoroscopy is abnormal if any degree of calcification is seen moving synchronously with the heart shadow in a location consistent with coronary artery anatomy by multiple views (Department of the Army, 1991b). Aircrew members with one or more level 2 screening abnormalities are referred for occupational, diagnostic evaluation in levels 3 and 4.

Level 3

Aircrew members entering level 3 are referred for non-invasive testing. The tests include 24-hour Holter monitor testing, echocardiogram, and thallium scan. Abnormalities found by these tests may result in medical termination of aviation service, and thus may be a contraindication for referring the aircrew member to level 4, invasive diagnostic testing. The most common contraindications found by level 3 testing are recurrent, aeromedically significant electrocardiographic arrhythmias and left ventricular hypertrophy (Mason, 1992).

Level 4

Aircrew members entering level 4 are referred for occupational, invasive diagnostic testing. The tests include left heart catheterization with coronary angiography and left ventriculography. Electrophysiologic studies are performed as indicated.

Appendix B.

Basic data set.

Table B-1.

Basic data set abbreviations table.

Abbreviation	Meaning
Table heading	
FRI	Framingham Risk Index in percent
TCHOL	Total serum cholesterol in mg/dl
TCHOL/HDL	Ratio of total serum cholesterol divided by serum high density lipoprotein cholesterol
GXT	Graded exercise treadmill test
Table body	
ECG	Electrocardiogram
ABN	Abnormal finding
BDR	Borderline abnormal finding
IR only	Intimal roughening of coronary artery only
NL	Normal finding
CX	Circumflex coronary artery
D1	First diagonal coronary artery
D2	Second diagonal coronary artery
LAD	Left anterior descending coronary artery
LM	Left main coronary artery
OM1	First obtuse marginal coronary artery
OM2	Second obtuse marginal coronary artery
OM3	Third obtuse marginal coronary artery
PDA	Posterior descending coronary artery
RCA	Right coronary artery

Table B-2.

Normal coronary arteries or intimal roughening (IR) only, and normal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal- lium	Coronary angiography
1.	54	5.1	210	4.8	NL	NL	IR only
2.	48	4.9	238	8.5	NL	BDR	IR only
3.	47	5.8	297	-	NL	-	normal

Table B-3.

Normal coronary arteries or intimal roughening (IR) only, and abnormal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal- lium	Coronary angiography
4.	46	2.0	184	6.1	ABN	NL	normal
5.	54	5.2	225	6.6	ABN	BDR	normal
6.	54	4.9	184	6.5	ABN	ABN	IR only
7.	53	5.7	227	5.8	ABN	BDR	normal
8.	46	4.0	259	6.3	ABN	BDR	IR only
9.	41	3.3	258	5.7	ABN	BDR	IR only
10.	51	10.2	270	7.7	ABN	NL	IR only
11.	51	5.2	238	6.8	ABN	BDR	+1 aortic insufficiency only
12.	50	5.2	271	5.3	ABN	NL	normal
13.	47	3.7	320	3.7	ABN	ABN	normal
14.	54	6.8	237	6.2	ABN	NL	normal

Table B-4.

Minimal coronary artery disease by angiography and normal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
15.	60	6.8	244	6.6	NL	ABN	CX- 10%,20% OM3-30% RCA-10%,30%
16.	52	7.4	209	4.7	NL	ABN	CX- 20% OM1-10% LAD-10%
17.	47	13.3	333	8.8	NL	NL	CX- 20% RCA-20%
18.	56	5.4	196	4.3	NL	NL	LAD-30%
19.	47	3.1	170	4.4	NL	BDR	LAD-20%,20%
	Note: Failed level 1 due to serial ECG changes and frequent multifocal premature ventricular contractions.						
20.	51	7.6	237	5.8	NL	ABN	LAD-20% D1- 10% OM2-10%
21.	48	8.0	247	4.9	NL	NL	LAD-30% RCA-30% CX- 30%
22.	55	11.0	232	6.8	NL	NL	LAD-10%,20%,20%
23.	56	8.7	257	6.3	NL	BDR	LAD-30% RCA-20%,20%,20% CX- 10%
24.	47	3.1	232	6.6	NL	NL	LAD-10%
25.	56	7.7	260	5.2	NL	NL	OM1-30% LAD-10%
26.	46	6.4	287	8.2	NL	-	LAD-10% CX- 10%
27.	45	5.7	263	8.2	NL	NL	RCA-10,%30% LAD-20% CX- 20%

Table B-4 (Continued).

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal- lium	Coronary angiography
28.	64	7.8	267	8.1	NL	NL	RCA-20% LAD-20%
29.	48	7.4	300	6.5	NL	-	LAD-20%
30.	49	4.4	235	7.6	NL	NL	LAD-30% RCA-10%
31.	52	4.1	235	6.2	NL	NL	LAD-20%
32.	50	6.6	230	5.6	NL	NL	LAD-20%
33.	51	7.8	275	-	NL	NL	CX- 20% OM1-20% LAD-10%

Table B-5.

Minimal coronary artery disease by angiography and abnormal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
34.	51	5.3	190	6.6	ABN	ABN	LAD-20% D1- 10% D2- 10% CX- 10%
35.	46	3.4	192	6.4	ABN	BDR	RCA-10%,20%
36.	45	6.3	253	7.9	ABN	BDR	LAD-10%,20%
37.	64	7.9	210	3.9	ABN	BDR	CX- 30% LAD-10%,10%,10%
38.	57	8.7	281	5.4	ABN	BDR	LAD-10%,20%
39.	47	3.3	204	6.2	ABN	NL	LAD-15%
40.	69	6.9	282	5.9	ABN	NL	RCA-10%,10%
41.	58	6.5	220	6.3	ABN	NL	LAD-15%
42.	43	3.0	261	6.9	ABN	NL	LAD-10%,20% RCA-10%
43.	44	3.0	242	6.9	ABN	BDR	LAD-20%
44.	57	7.8	262	4.9	ABN	NL	RCA-20%

Table B-6.

Significant coronary artery disease by angiography and normal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
45.	55	11.0	277	9.9	NL	BDR	CX- 70% D1- 40%,50% OM1-50% LAD-20% LM- 20%
46.	61	8.1	253	6.8	NL	BDR	RCA-10%,20%,50% LAD-30%,40%,40% OM2-30% LM- 10%
47.	57	7.1	211	-	NL	-	LAD-10%,10%,70% CX- 40% RCA-10%,10%,20%
48.	57	16.0	320	4.7	NL	ABN	RCA-99%,100% D1- 65% CX- 60% OM1-50% LM- 30%
49.	40	1.6	186	10.3	NL	BDR	RCA-90%,100% LAD-20% CX- 20%
50.	50	5.7	204	6.2	NL	NL	PDA-50% LAD-40% CX- 20%,30%
51.	57	9.6	211	4.5	NL	NL	D1- 50%,60% CX- 50%,60%
52.	62	9.1	253	-	NL	NL	CX- 30%,30%,60% OM1-50% RCA-40% LAD-10%,10%,10%
53.	56	9.3	208	8.0	NL	NL	OM2-80% LAD-20%,60%,70% OM1-60% CX- 60% RCA-30%,30%,30%

Table B-6 (Continued).

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal- lium	Coronary angiography
54.	58	6.3	200	3.5	NL	ABN	D1- 60% LAD-40% RCA-20%
55.	50	3.6	227	6.3	NL	NL	RCA-60% LAD-10%,30%
56.	54	7.8	274	8.5	NL	NL	LAD-40%,50% OM2-20% RCA-15% CX- 10%
57.	52	5.4	214	4.4	NL	ABN	LAD-100% CX- 80% RCA-70%

Table B-7.

Significant coronary artery disease by angiography and abnormal graded exercise treadmill test.

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
58.	62	8.1	208	5.8	ABN	ABN	LAD-30%,40%,70%
59.	45	5.4	289	7.2	ABN	NL	RCA-95%
60.	45	4.4	264	7.5	ABN	BDR	LAD-40% D1- 40% D2- 30% RCA-20%,20%,20% LM-20%
61.	58	8.8	286	7.9	ABN	NL	OM1-40% LAD-20%,30% RCA-10%
62.	55	8.0	178	4.7	ABN	NL	RCA-10%,30%,40%
63.	54	5.6	169	5.1	ABN	BDR	LAD-40%
64.	50	5.4	231	6.2	ABN	ABN	RCA-80%,90%,99% OM1-90% CX- 80% LAD-30%,30%,40% OM2-20%,40%
65.	46	13.5	343	9.3	ABN	ABN	RCA-95% CX- 95% LAD-30%
66.	46	2.3	226	8.7	ABN	-	OM1-60% CX-30%,50% LAD-20%,30%
67.	48	7.4	248	3.0	ABN	-	D2- 99% LAD-20%,20%
68.	53	6.0	260	6.0	ABN	ABN	RCA-95% LAD-50%,80% OM2-60% CX- 60%

Table B-7 (Continued).

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
69.	48	4.6	192	4.2	ABN	NL	RCA-100% LM- 20% LAD-20%
	Note: Failed level 1 due to serial ECG changes.						
70.	58	7.8	246	5.9	ABN	ABN	PDA-95% LAD-40%,50% D1- 50% RCA-20%,20%30%
71.	52	4.6	223	6.0	ABN	ABN	RCA-100% CX- 20%,50% LAD-20%
72.	41	1.7	228	6.3	ABN	BDR	LAD-50%
73.	43	5.8	275	6.4	ABN	ABN	RCA-70%,80%,80% OM3-60% OM2-40%
74.	55	10.5	224	2.7	ABN	NL	OM1-100% OM2-100%,100% D1-70%,70% LAD-30%,40%,70% RCA-20%,20%,50% LM- 20%
75.	50	5.4	205	6.2	ABN	NL	LAD-60% CX- 40%
76.	43	1.5	186	5.5	ABN	BDR	LAD-60% CX- 20%,50%,50% RCA-10%,50% LM- 30%
	Note: Failed level 1 due to serial ECG changes.						
77.	63	6.9	187	6.2	ABN	BDR	PDA-20%,50% CX-10%,20% LAD-20% D1- 20%
78.	50	6.3	211	5.7	ABN	ABN	RCA-80% LM- 70% LAD-50%

Table B-7 (Continued).

Patient number	Age	FRI	TCHOL	TCHOL/ HDL	GXT	Thal-lium	Coronary angiography
79.	53	7.6	270	-	ABN	-	CX- 99% OM1-99% PDA-95% LAD-95% RCA-50% LM- 30%
80.	50	8.4	250	4.3	ABN	ABN	PDA-90%,90% D1- 30%,30%,75% CX- 30%
81.	56	9.9	203	-	ABN	ABN	LAD-99%
82.	58	7.3	196	3.6	ABN	NL	PDA-100% LAD-75% RCA-75% CX- 30%

Appendix C.

Framingham Risk Index formula calculation.

Framingham Risk Index formula calculation.

$$\text{Framingham Risk Index} = \frac{1}{1 + e^{-\text{coeff}}}$$

The variable "coeff" is the total beta coefficient and is derived from the multiple logistic regression analysis formula (Gordon, Sorlie, and Kannel, 1971):

total beta coeff = ß0* +
(ß1 x age) +
(ß2 x age^2) +
(ß3 x age x total cholesterol in mg/dl) +
(ß4 x total cholesterol in mg/dl) +
(ß5 x systolic blood pressure in mmHg) +
(ß6 x smoking history**) +
(ß7 x LVH on EKG***) +
(ß8 x diabetes****)

Table C-1.

Framingham Risk Index beta coefficients by gender.

Factor	Gender is male	Gender is female
ß0	-22.227532	-19.066572
ß1	0.460575	0.311558
ß2	-0.002882	-0.001724
ß3	-0.000416	-0.000190
ß4	0.028590	0.016802
ß5	0.012444	0.015278
ß6	0.447815	0.049966
ß7	0.743158	0.441707
ß8	0.265016	0.416906

Notes:

* Factors "ß0" through "ß8" are gender adjusted and are listed in Table C-1.

** For the variable "smoking history," the value is "1" if smoking history is 10 or greater cigarettes per day, and value is "0" if smoking history is less than 10 cigarettes per day.

*** For the variable "LVH," the value is "1" if left ventricular hypertrophy is found on electrocardiogram (EKG); and value is "0" if there is no left ventricular hypertrophy on EKG, or left ventricular hypertrophy by voltage only criteria.

**** For the variable "diabetes," the value is "1" if the fasting blood glucose is 115 mg/dl or greater, and the value is "0" if the fasting blood glucose is less than 115 mg/dl.

Appendix D.

Descriptive summary tables.

Table D-1.

Age distribution.

In years	40-44	45-49	50-54	55-59	60+
Total	7	22	26	19	8

Table D-2.

Total serum cholesterol distribution.

In mg/dl	<200	200-219	220-239	240-259	≥260
Total	15	17	15	12	23

Table D-3.

Total cholesterol/HDL cholesterol ratio distribution.

Ratio	<4.0	4.0-5.9	6.0-7.9	8.0-9.9	≥10.0
Total*	6	30	30	9	1

Note: * Six aircrew members had no HDL cholesterol on file

Table D-4.

Framingham Risk Index distribution.

In percent	<5.0	5.0-7.4	7.4-9.9	≥10.0
Total	24	29	20	9