# Effect of perioperative complications on excess mortality among women after coronary artery bypass: The Israeli Coronary Artery Bypass Graft study (ISCAB)

Yana Zitser-Gurevich, MD, MPH[a]
Elisheva Simchen, MD, MPH[a,b]
Noya Galai, PhD[a,c]
Micha Mandel, MA[a]
The ISCAB Consortium[d*]

**Background:** Widely observed excess mortality among women after coronary artery bypass grafting is still largely unexplained, although case-mix factors have been identified. We evaluated the contribution of perioperative complications to the risk of 180-day mortality among women while adjusting for case-mix factors.

**Methods:** This is part of a prospective, 1-year nationwide Israeli coronary artery bypass graft study of 1029 female and 3806 male patients. Deaths within 180 days were independently ascertained. Case-mix risk strata were obtained from a pooled Cox survival model (including all subjects and study variables) by using the adjusted coefficients corresponding to the case-mix factors within the model. Sex-specific mortality associated with perioperative complications was evaluated within the strata. In addition, sex-specific Cox models were constructed.

**Results:** Higher mortality among women compared with that among men was significant within the pooled model (hazard ratio, 1.4; $P = .038$) and was evident early in the postoperative period. Women tended to cluster in the highest risk quartile compared with men (39.8% vs 20.9%, $P < .001$). However, although the incidence of perioperative complications was similar for the 2 sexes, the associated mortality for a given perioperative complication was higher among women. Sex-specific Cox models confirmed the above findings. For example, the hazard ratio for women with low postoperative hemoglobin was 6.9, whereas for men, the hazard ratio was 3.9.

**Conclusions:** The role of perioperative factors in the excess mortality among women after coronary artery bypass grafting shifts the focus of attention from the selection of women for the operation to the in-hospital experience. Improving the outcome for women will entail efforts to prevent complications in the perioperative period.

From the Department of Health Services Research, Ministry of Health,[a] Jerusalem, the School of Public Health, Hebrew University and Hadassah Medical Organization,[b] Jerusalem, and the Department of Epidemiology, Ben-Gurion University of the Negev,[c] Beer-Sheva, Israel, and all the cardiac departments in Israel.[d]

Source of funding: Ministry of Health, Israel.

Received for publication May 30, 2001; revisions requested July 31, 2001; revisions received Aug 16, 2001; accepted for publication Aug 30, 2001.

Address for reprints: E. Simchen, MD, MPH, School of Public Health, Hadassah Medical Center, Ein Kerem, Jerusalem 91120, Israel (E-mail: sara.sachs@moh.health.gov.il).

*The ISCAB Consortium: Azay Appelbaum, Nima Amit, Yaron Barel, Yitzhak Berlovitz, Dani Biteran, Amram Cohen, Elieser Kaplinsky, Jacob Lavee, Gideon Merin, Simcha Milo, Benjamin Mozes, Gideon Oretzki, Gideon Sahar, Arie Schachner, Aram Smolenski, Bernardo Vidne, and Vladimir Yakirevitch.

J Thorac Cardiovasc Surg 2002;123:517-24



0022-5223/2002 $35.00 + 0 **12/1/120012**

doi:10.1067/mtc.2002.120012

ACD

Outcome studies in patients undergoing coronary artery bypass grafting (CABG) have shown consistently that women are at higher risk for postoperative mortality.[1-11] Several factors associated with the excess mortality in women are discussed in the literature, suggesting a greater severity of illness before the operation. Higher prevalence of known risk factors, such as older age,[1-9] diabetes mellitus,[1-6] obesity,[5-7] hypertension,[5-8] renal dysfunction,[5] and advanced coronary artery disease,[6,12] were found in women. Delayed referral of women for surgical intervention was also cited as a possible explanation for sex differences in mortality.[13] Smaller coronary vessels in women were thought to predispose them to technical difficulties during the operation, resulting in incomplete

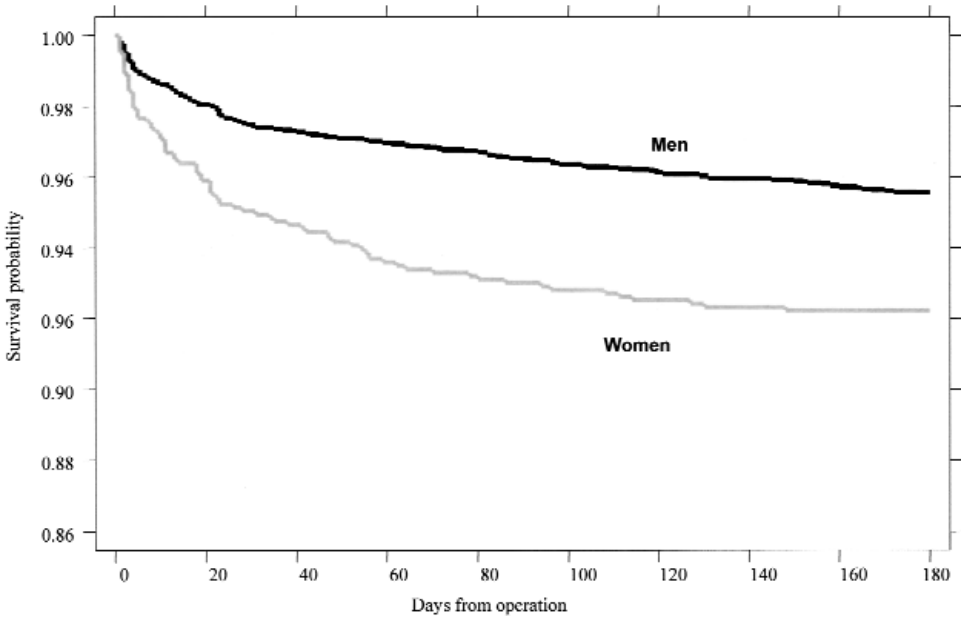


**Figure 1. Observed 180-day survival after CABG: women versus men.**

revascularization[14] and reduced use of arterial grafts.[2,10] However, few reports have focused on sex differences in perioperative complications. Utley and colleagues[3] compared the incidence of postoperative complications without adjustment for case-mix factors.

The present study is part of a nationwide study of patients undergoing CABG in 1994, with complete follow-up of patients from admission to discharge and mortality up to 180 days after surgical intervention. The analysis attempts to evaluate the independent contribution of perioperative complications to mortality among women adjusting for on-admission risk.

ACD

## Methods

This report is a part of the National Israeli CABG Study, which was carried out in all 14 cardiac surgery departments in Israel in 1994. All the patients undergoing isolated CABG during the period from January 1, 1994, to December 31, 1994, were included. The present report was based on 4835 patients (3806 men and 1029 women), representing 95% of the total target population. The 265 patients who had not completed the baseline interview because of staff vacations were excluded from the analysis. A detailed description of the study is given elsewhere.[15]

In brief, information was collected prospectively by a team of specially trained nurses. The information included patient's demographic characteristics and health practices, which were obtained from a personal interview before the operation. The clinical history was obtained both from personal interview and medical records, and the severity of coronary disease was verified with catheterization reports. Information on the operative variables was extracted from the operation reports filled out by the surgeons. Information on the postoperative variables was obtained by means of daily follow-up of the patients until discharge or death, whichever was earlier. Data collection was standardized and supervised throughout the year. The study was monitored by a steering committee consisting of the heads of all cardiac surgery departments in the country.

Six-month mortality was chosen as the outcome of interest, assuming that within this time frame, death could be reasonably attributed to the surgical procedure.

Deaths were verified by linkage to the national death records, regardless of hospitalization status.

Survival patterns among men and women until the 180th postoperative day were evaluated by using the Kaplan-Meier estimate.

A pooled Cox model including both sexes and all study variables (case-mix factors and perioperative complications) was constructed in the usual manner to estimate the independent effect of perioperative factors on mortality. Similarly, 2 sex-specific models were developed. The models' performance was evaluated with the Harrel c statistics.[16]

The pooled model was used for comparison with the sex-specific models and to form on-admission risk strata by using the partial score corresponding to the β-coefficients of the case-mix factors within the model, excluding the sex variable. This partial score reflected the net effect of case-mix factors because they were already adjusted for the later complications. The sex-specific incidence and effect of perioperative factors were then evaluated within quartiles of risk. Finally, 2 sex-specific Cox models were constructed, including variables significant in either model.

## Results

Of the 4835 CABG operations in Israel in 1994, only 1029 (21.3%) were performed in women. The mortality rate for

**TABLE 1. Comparison of 3 Cox models for mortality risk within 180 days after CABG: ISCAB, 1994**

| | All Patients | | Men | | Women | |
|---|---|---|---|---|---|---|
| Variable | HR* | *P* value | HR* | *P* value | HR* | *P* value |
| Case mix | | | | | | |
| Female sex | 1.35 | .038 | — | — | — | — |
| Age ≥75 y | 1.83 | .000 | (1.38) | .095 | 3.30 | .000 |
| Emergency operation | 3.67 | .000 | 4.77 | .000 | (2.33) | .084 |
| Urgent operation | 1.33 | .045 | (1.36) | .098 | (1.39) | .221 |
| Cancer | 2.45 | .019 | 2.86 | .028 | (2.33) | .274 |
| Extreme BMI† | 2.08 | .013 | (1.14) | .801 | 4.46 | .000 |
| Diabetes mellitus | 1.84 | .000 | 1.55 | .010 | 2.94 | .000 |
| Severe LVD | 1.70 | .004 | 1.86 | .007 | (1.08) | .584 |
| Moderate LVD | 1.41 | .046 | 1.76 | .007 | (1.20) | .209 |
| Renal dysfunction | 1.69 | .001 | 1.92 | .000 | (1.27) | .613 |
| Physical activity‡ | 0.43 | .000 | 0.46 | .000 | 0.27 | .007 |
| Operative | | | | | | |
| Intraoperative complications§ | 2.62 | .000 | 2.40 | .000 | 5.54 | .000 |
| Intraoperative IABP | 1.91 | .002 | 2.47 | .000 | (0.81) | .640 |
| No crossclamp | 1.84 | .048 | (1.74) | .162 | (1.76) | .264 |
| Incomplete revascularization | 1.72 | .000 | 1.77 | .001 | (1.26) | .393 |
| Postoperative predischarge period | | | | | | |
| Hemoglobin <8 mmol/L | 4.01 | .000 | 3.93 | .000 | 6.86 | .000 |
| Cerebrovascular accident | 3.56 | .000 | 4.25 | .000 | 2.18 | .050 |
| On respirator ≥24 h | 2.93 | .000 | 2.42 | .000 | 3.67 | .000 |
| Myocardial infarction | 2.92 | .000 | 2.23 | .009 | 6.68 | .000 |
| Heart failure | 2.43 | .000 | 2.42 | .000 | 2.44 | .007 |
| Arrhythmia | 1.79 | .004 | 1.93 | .007 | 1.97 | .054 |
| Additional operation | 1.71 | .004 | 1.86 | .006 | (1.56) | .183 |
| Steroid therapy | 1.64 | .001 | 1.69 | .004 | (1.53) | .148 |
| Transfusions ≥5 portions | (1.06) | .692 | (0.92) | .705 | 1.92 | .047 |
| c statistics | 0.900 | | 0.899 | | 0.915 | |

*LVD*, Left ventricular dysfunction; *BMI*, body mass index; *IABP*, intra-aortic balloon pump.
*Hazard ratio derived from the Cox model approximates the relative risk.
†The model included a category for missing values of BMI, which were significantly associated with mortality.
‡In the model physical activity entered as a protective factor.
§Definition on the basis of specific diagnoses, such as intraoperative massive bleeding and additional grafts.

ACD

the total population within 180 days after CABG was 5.1%, which is similar to that of other published reports.[17,18] The corresponding mortality rates in women and men were 7.8% and 4.4%, respectively (relative risk, 1.8; $P < .01$). The Kaplan-Meier survival curves for women and men are presented in Figure 1, demonstrating that the divergence of the survival curve for women occurred early in the perioperative period. Later, the 2 survival curves run parallel.

Women had a different social profile than men (univariate analysis, Appendix 1), being older, less educated, more of immigrant origin, less gainfully employed, and less frequently employed in academic professions and more frequently having no spouse or living alone. However, sociodemographic factors did not seem to affect 180-day mortality. Women presented with higher proportions of the majority of screened preoperative clinical factors but the same proportion of perioperative complications. The absolute effect of single preoperative factors on mortality among women relative to men varied only slightly. By contrast, for perioperative factors, the mortality among women was extremely high.

The relative effect of various factors on mortality within the sexes was strongly affected by the high mortality in the reference group among women. For example, although the absolute mortality rate in women with 3-vessel disease and left main involvement was 15.7% versus 7.4% in men, the relative risks for the 2 sex groups were similar (2.9 and 2.6, respectively) because of the high mortality rate in the reference group among women (Appendix 1).

A pooled multivariate Cox model was constructed to evaluate the independent effect of all study variables on 180-day mortality. Generally, it demonstrated stronger effects for perioperative complications compared with case-mix factors. The relative risk associated with female sex

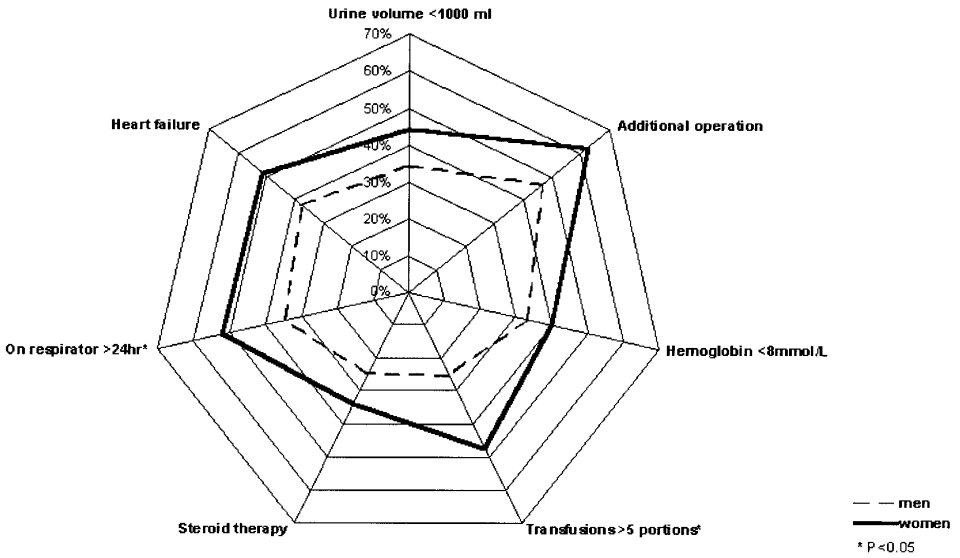


**Figure 2. Mortality at 180 days for perioperative complications among women versus men in the highest quartile of on-admission risk.**

after controlling for all significant factors within the model was 1.35 ($P$ = .038, Table 1).

The pooled model was used to form on-admission risk quartiles by using the β-coefficients of the case-mix factors within the model. These quartiles were used to compare the sexes for the frequency and effect of perioperative factors. More women relative to men were observed in the high-risk quartile (39.8% vs 20.9%, $P$ < .001). Perioperative complications occurred with the same frequency among the sexes within corresponding levels of risk. However, in the highest quartile the associated mortality was significantly higher among women relative to men (Figure 2) for such factors as prolonged mechanical ventilation (51.6% vs 34.4%, $P$ = .017) and need for blood transfusions (47.5% vs 25.3%, $P$ = .001). Great differences in mortality rates were also observed for myocardial infarction, additional operation, heart failure, urine volume of less than 1000 mL, and steroid therapy. However, they did not achieve statistical significance because of small numbers.

Finally, sex-specific Cox models (Table 1) reemphasized the strong effect of perioperative complications on mortality, especially among female patients. Among these factors in the female model were intraoperative complications (hazard ratio [HR], 5.5; $P$ < .000), postoperative low hemoglobin (HR, 6.9; $P$ < .000), postoperative myocardial infarction (HR, 6.7; $P$ = .009), time on respirator of greater than 24 hours (HR, 3.7; $P$ < .000), and transfusions over 5 portions (HR, 1.9; $P$ = .05). In addition, other interesting findings in the female model were the unique effect of extreme body mass index and age over 75 years.

## Discussion

We examined the hypothesis that perioperative factors were especially important when attempting to explore sex differences in mortality because significant sex differences were found in the operative technique: incomplete revascularization in women[14] and diminished use of internal thoracic artery grafts,[2] as well as differences in mortality related to the prevalent use of exclusive venous grafting in women.[10]

Proposed explanations in the literature for sex differences in mortality after CABG usually center on a more severe patient profile among women.[7] It is assumed that residual variability in mortality after adjusting for case-mix is usually a result of patient care, but surgical technique is hard to quantify, and meaningful data on the operation and the postoperative period are hard to get. However, there is evidence from published reports that patient experience in the hospital is important. Duration of the operation, type of grafting used, reexploration for bleeding, intraoperative complications, inability to wean patients off respirators, need for inotropic drugs and blood transfusions, and development of wound infections have all been shown to be associated with mortality after CABG.[19-23] In a previous report we suggested that not all complications during the operation and the perioperative period could be attributed to patient inherent risk at the time of the operation.[15] Furthermore, the sequential addition of the operative and postoperative factors to the case-mix characteristics suggested an independent effect of these factors on mortality.

Using detailed information on inherent patient characteristics at entry to the hospital and during the operation and

the postoperative period enabled us to isolate the effect of perioperative factors while adjusting for patients' on-admission risk within a Cox model.

Our study confirmed previous reports demonstrating that risk factors are more prevalent in women than in men before the operation.[1-11] However, in contrast to other studies,[3] we found no significant sex differences in the incidence of postoperative complications.

The main finding in the present study was that perioperative complications tended to be more lethal for women. For example, women with postoperative myocardial infarction had a 3-fold risk of dying relative to men with the same complication, and those with low postoperative hemoglobin or multiple transfusions had twice the probability of dying relative to men (Table 1). Although our study sample included 1029 women, it is possible that with a larger sample size some additional risk factors would have entered the female model.

The differential effect on mortality for perioperative factors was especially prominent among patients in the upper quartile of on-admission risk. Although the overall sex-specific crude 180-day mortality rates were relatively low (7.8% vs 4.4% for women and men, respectively), the rates associated with perioperative complications in the upper risk quartile were of a different order of magnitude, especially for women: with additional surgery, 63% mortality; with prolonged mechanical ventilation, 51%; with multiple transfusions, 48%; and with low hemoglobin, 40% (Figure 2). The fact that perioperative complications were less well tolerated by female patients may be due in part to the inherent risk of female patients undergoing an operation. However, the possibility that surgeons experienced more difficulties in managing complications in high-risk female patients should also be considered.

Recently, publications have shifted the attention concerning mortality among women undergoing CABG from a biased selection of female patients for surgical intervention to the actual surgical event. O'Connor and colleagues[24] found that interventions by reviewing operative technique resulted in reducing mortality after CABG. Petro and coworkers[25] reported encouraging results from minimally invasive procedures among women. However, although the standard CABG is a common procedure, our findings lend support to the continuing efforts to manage female patients with extra care to avoid perioperative complications.

## References


1. Hammar N, Sandberg E, Larsen FF, Ivert T. Comparison of early and late mortality in men and women after isolated coronary artery bypass graft surgery in Stockholm, Sweden, 1980 to 1989. *J Am Coll Cardiol.* 1997;29:659-64.
2. O'Connor GT, Morton JR, Diehl MJ, Olmstead EM, Coffin LH, Levy DG, et al. Differences between men and women in hospital mortality associated with coronary artery bypass graft surgery. *Circulation.* 1993;88:2104-10.
3. Utley JR, Wilde EF, Leyland SA, Morgan MS, Johnson HD. Intraoperative blood transfusion is a major risk factor for coronary artery bypass grafting in women. *Ann Thorac Surg.* 1995;60:570-5.
4. Richardson JV, Cyrus RJ. Reduced efficacy of coronary artery bypass grafting in women. *Ann Thorac Surg.* 1986;42(suppl):S16-21.
5. Herlitz J, Brandrup-Wognsen G, Karlson BW, Sjoland H, Caidahl K, Hartford M, et al. Mortality, risk indicators of death, mode of death and symptoms of angina pectoris during 5 years after coronary artery bypass grafting in men and women. *J Intern Med.* 2000;247:500-6.
6. Edwards FH, Carey JS, Grover FL, Bero JW, Hartz RS. Impact of gender on coronary bypass operative mortality. *Ann Thorac Surg.* 1998;66:125-31.
7. Hannan LW, Bernard HR, Kilburn HC, O'Donnel JF. Gender differences in mortality rates for coronary artery bypass surgery. *Am Heart J.* 1992;123:866-72.
8. Farrer M, Skinner JS, Albers CJ, Alberti KGMM, Adams PC. Outcome after coronary artery surgery in women and men in the North of England. *Q J Med.* 1997;90:203-11.
9. Carey JS, Cukingnan RA, Singer LKM. Health status after myocardial revascularization: inferior results in women. *Ann Thorac Surg.* 1995;59:112-7.
10. Simchen E, Israeli A, Merin G, Ferderber N. Israeli women were at a higher risk than men for mortality following coronary bypass surgery. *Eur J Epidemiol.* 1997;13:503-9.
11. Jaglar SB, Tu JV, Naylor CD. Higher in-hospital mortality in female patients following coronary artery bypass surgery: a population-based study. Provincial Adult Cardiac Care Network of Ontario. *Clin Invest Med.* 1995;18:99-107.
12. Christakis GT, Weisel RD, Buth KJ, Fremes SE, Rao V, Panagiotopoulos KP, et al. Is body size the cause for poor outcomes of coronary artery bypass operations in women? *J Thorac Cardiovasc Surg.* 1995;110:1344-56.
13. Khan SS, Nessim S, Gray R, Czer LS, Chaux A, Matloff J. Increased mortality of women in coronary artery bypass surgery: evidence for referral bias. *Ann Intern Med.* 1990;112:561-7.
14. Douglas JS Jr, King SB 3rd, Jones EL, Craver JM, Bradford JM, Hatcher CR Jr. Reduced efficacy of coronary bypass surgery in women. *Circulation.* 1981;64(Suppl):II-11-6.
15. Simchen E, Galai N, Zitser-Gurevich Y, Braun D, Mozes B. Sequential logistic models for 30 days mortality after CABG: preoperative, intra-operative and post-operative experience-The Israeli CABG study (ISCAB). Three models for early mortality after CABG. *Eur J Epidemiol.* 2000;16:543-55.
16. Harrell FE, Kerry LL, Califf RM, Pryor DB, Rosati RA. Regression modeling strategies for improved prognostic prediction. *Stat Med.* 1984;3:143-52.
17. Rumsfeld JS, MaWhinney S, McCarthy M Jr, Shroyer AL, VillaNueva CB, O'Brien M, et al. Health-related quality of life as a predictor of mortality following coronary artery bypass graft surgery. Participants of the Department of Veterans Affairs Cooperative Study Group on Processes, Structures, and Outcomes of Care in Cardiac Surgery. *JAMA.* 1999;281:1298-303.
18. Noyez L, Verheugt FW, Peppelenbosch AG, Skotnicki SH, Brouwer MH. Aortocoronary bypass surgery: at least 6 months follow-up required for assessment of postoperative course. *Ned Tijdschr Geneeskd.* 2000;144:1874-7.
19. He GW, Acuff TE, Ryan WH, Bowman RT, Douthit MB, Mack MJ. Determinants of operative mortality in elderly patients undergoing coronary artery bypass grafting: emphasis on the influence of internal mammary artery grafting on mortality and morbidity. *J Thorac Cardiovasc Surg.* 1994;108:73-81.
20. Leavitt BJ, O'Connor GT, Olmstead EM, Morton JR, Maloney CT, Dacey LJ, et al. Use of the internal mammary artery graft and in-hospital mortality and other adverse outcomes associated with coronary artery bypass surgery. *Circulation.* 2001;103:507-12.
21. Louagie Y, Buche M, Jamart J, Eucher P, Haxhe JP, Schoevaerdts JC. Operative risk assessment in coronary artery bypass surgery, 1990-1993: evaluation of perioperative variables. *Thorac Cardiovasc Surg.* 1995;43:134-41.
22. Moulton MJ, Creswell LL, Mackey ME, Cox JL, Rosenbloom M.

Reexploration for bleeding is a risk factor for adverse outcomes after cardiac operations. *J Thorac Cardiovasc Surg.* 1996;111:1037-46.
23. Brandrup-Wognsen G, Haglid M, Karlsson T, Berggren H, Herlitz J. Mortality during the two years after coronary artery bypass grafting in relation to perioperative factors and urgency of operation. *Eur J Cardiothorac Surg.* 1995;9:685-91.
24. O'Connor GT, Plume SK, Olmstead EM, Morton JR, Maloney CT, Nugent WC, et al. A regional intervention to improve the hospital mortality associated with coronary artery bypass graft surgery. The Northern New England Cardiovascular Disease Study Group. *JAMA.* 1996;275:841-6.
25. Petro KR, Dullum MK, Garcia JM, Pfister AJ, Qazi AG, Boyce SW, et al. Minimally invasive coronary revascularization in women: a safe approach for a high-risk group. *Heart Surg Forum.* 2000;3:41-6.

**APPENDIX 1. Univariate analysis of 180-day mortality after CABG among women versus men (only significant associations in either sex): ISCAB, 1994**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| **Risk factors** | **n** | **Mortality rate (%)** | **Cox HR** | **n** | **Mortality rate (%)** | **Cox HR** |
| Case-mix factors | | | | | | |
| Age (y) | | | | | | |
| <65 | 1959 | 2.8 | 1.0 | 334 | 5.4 | 1.0 |
| 65-74 | 1431 | 5.2 | 1.9† | 532 | 7.7 | 1.4 |
| ≥75 | 416 | 9.9 | 3.7† | 163 | 12.9 | 2.4† |
| Extreme BMI (<20, >35) | | | | | | |
| No | 3584 | 3.8 | 1.0 | 887 | 6.1 | 1.0 |
| Yes | 73 | 5.5 | 1.4 | 56 | 16.1 | 2.8† |
| Missing | 149 | 18.8 | 5.5† | 86 | 19.8 | 3.5† |
| Physical activity | | | | | | |
| No | 1962 | 5.1 | 1.0 | 749 | 8.8 | 1.0 |
| Yes | 1717 | 2.0 | 0.4† | 253 | 2.0 | 0.2† |
| Hospitalization in past 2 years | | | | | | |
| No | 3285 | 3.6 | 1.0 | 807 | 7.7 | 1.0 |
| Yes (≥3) | 521 | 9.0 | 2.7† | 222 | 8.1 | 1.0 |
| Type of operation | | | | | | |
| Elective | 2360 | 3.0 | 1.0 | 519 | 5.0 | 1.0 |
| Urgent | 1370 | 6.0 | 2.0† | 478 | 9.8 | 2.0* |
| Emergency | 76 | 22.4 | 8.9† | 32 | 21.9 | 4.9† |
| Recent myocardial infarction | | | | | | |
| No | 3708 | 4.3 | 1.0 | 995 | 7.5 | 1.0 |
| Yes | 98 | 10.2 | 2.4† | 34 | 14.7 | 2.0 |
| Left ventricle dysfunction | | | | | | |
| No | 3241 | 3.3 | 1.0 | 746 | 6.9 | 1.0 |
| Moderate | 350 | 9.4 | 2.9† | 163 | 9.8 | 1.4 |
| Severe | 215 | 13.0 | 4.1† | 120 | 10.0 | 1.4 |
| Extent of coronary disease | | | | | | |
| 1- to 2-vessel disease | 1722 | 2.4 | 1.0 | 440 | 5.9 | 1.0 |
| 1- to 2-vessel disease with LMD | 373 | 5.9 | 2.1† | 142 | 5.6 | 0.9 |
| 3-vessel disease without LMD | 1468 | 5.4 | 1.9† | 377 | 9.3 | 1.6* |
| 3-vessel disease with LMD | 243 | 7.4 | 2.6† | 70 | 15.7 | 2.9† |
| Diabetes mellitus | | | | | | |
| No | 2755 | 3.7 | 1.0 | 642 | 4.7 | 1.0 |
| Yes | 1051 | 6.5 | 1.8† | 387 | 12.9 | 2.8† |
| Arrhythmia | | | | | | |
| No | 3307 | 3.9 | 1.0 | 859 | 7.6 | 1.0 |
| Yes | 499 | 7.8 | 2.0† | 170 | 8.8 | 1.1 |
| Peripheral vascular disease | | | | | | |
| No | 3448 | 3.9 | 1.0 | 940 | 7.8 | 1.0 |
| Yes | 358 | 9.5 | 2.5† | 89 | 7.9 | 1.0 |

**APPENDIX 1. Continued**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| **Risk factors** | **n** | **Mortality rate (%)** | **Cox HR** | **n** | **Mortality rate (%)** | **Cox HR** |
| Chronic obstructive pulmonary disease | | | | | | |
| No | 3581 | 4.1 | 1.0 | 975 | 7.9 | 1.0 |
| Yes | 225 | 10.2 | 2.6† | 54 | 5.6 | 0.7 |
| History of cerebrovascular disease | | | | | | |
| No | 3526 | 4.0 | 1.0 | 943 | 7.5 | 1.0 |
| Transient ischemic attack | 93 | 8.6 | 2.1* | 32 | 6.2 | 0.8 |
| Cerebrovascular accident | 184 | 9.8 | 2.5† | 54 | 13.0 | 1.8 |
| Renal dysfunction | | | | | | |
| No | 3343 | 3.3 | 1.0 | 968 | 7.5 | 1.0 |
| Yes | 463 | 13.0 | 4.1† | 61 | 11.5 | 1.5 |
| Perioperative factors | | | | | | |
| Intraoperative complications‡ | | | | | | |
| No | 3583 | 3.5 | 1.0 | 967 | 6.1 | 1.0 |
| Yes | 223 | 19.3 | 6.3† | 62 | 32.3 | 6.3† |
| Intraoperative IABP | | | | | | |
| No | 3723 | 3.7 | 1.0 | 1000 | 6.6 | 1.0 |
| Yes | 83 | 38.5 | 13.5† | 29 | 48.3 | 10.1† |
| Type of graft | | | | | | |
| Others | 3559 | 3.8 | 1.0 | 925 | 7.3 | 1.0 |
| Vein only | 247 | 13.4 | 3.7† | 104 | 11.5 | 1.6 |
| Crossclamp time per graft | | | | | | |
| ≤25 min | 3152 | 4.0 | 1.0 | 851 | 7.5 | 1.0 |
| >25 min | 391 | 7.4 | 2.1† | 103 | 7.8 | 1.2 |
| No crossclamp | 123 | 5.7 | 1.6 | 27 | 18.5 | 2.9* |
| Incomplete revascularization | | | | | | |
| No | 3017 | 3.7 | 1.0 | 802 | 6.7 | 1.0 |
| Yes | 789 | 7.3 | 2.0† | 227 | 11.5 | 1.7* |
| Postoperative myocardial infarction | | | | | | |
| No | 3643 | 4.0 | 1.0 | 980 | 6.7 | 1.0 |
| Yes | 163 | 14.8 | 3.9† | 49 | 28.6 | 4.9† |
| Postoperative heart failure | | | | | | |
| No | 3739 | 3.9 | 1.0 | 993 | 6.2 | 1.0 |
| Yes | 67 | 35.8 | 11.0† | 36 | 50.0 | 10.7† |
| Postoperative on respirator for >24 h | | | | | | |
| No | 3422 | 2.4 | 1.0 | 903 | 4.1 | 1.0 |
| Yes | 384 | 22.7 | 10.5† | 126 | 34.1 | 9.8† |
| Postoperative stroke | | | | | | |
| No | 3710 | 3.7 | 1.0 | 1000 | 6.9 | 1.0 |
| Yes | 96 | 33.3 | 10.3† | 29 | 37.9 | 6.4† |
| Urine volume <1000 mL | | | | | | |
| No | 3594 | 3.8 | 1.0 | 952 | 6.5 | 1.0 |
| Yes | 212 | 14.6 | 4.1† | 77 | 23.4 | 4.0† |
| Additional operation | | | | | | |
| No | 3635 | 3.5 | 1.0 | 974 | 5.2 | 1.0 |
| Yes | 171 | 25.1 | 8.3† | 55 | 52.7 | 13.8† |
| Hemoglobin <8 mmol/L | | | | | | |
| No | 3545 | 3.6 | 1.0 | 948 | 6.0 | 1.0 |
| Yes | 261 | 16.1 | 5.0† | 81 | 28.4 | 5.8† |
| Postoperative intestinal bleeding | | | | | | |
| No | 3693 | 4.2 | 1.0 | 1013 | 7.3 | 1.0 |
| Yes | 113 | 10.6 | 2.5† | 16 | 37.5 | 6.1† |
| Mediastinitis or sepsis | | | | | | |
| No | 3712 | 3.6 | 1.0 | 985 | 5.9 | 1.0 |
| Yes | 94 | 38.3 | 12.4† | 44 | 47.7 | 8.3† |

**APPENDIX 1. Continued**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| **Risk factors** | **n** | **Mortality rate (%)** | **Cox HR** | **n** | **Mortality rate (%)** | **Cox HR** |
| Transfusions (≥5 portions) | | | | | | |
| No | 3321 | 3.3 | 1.0 | 915 | 4.8 | 1.0 |
| Yes | 485 | 12.6 | 4.1† | 114 | 31.6 | 7.6† |
| Steroid therapy | | | | | | |
| No | 3112 | 3.3 | 1.0 | 858 | 5.9 | 1.0 |
| Yes | 694 | 9.4 | 2.9† | 171 | 17.0 | 3.0† |
| Postoperative arrhythmia | | | | | | |
| No | 1837 | 2.0 | 1.0 | 467 | 3.9 | 1.0 |
| Yes | 1969 | 6.8 | 3.5† | 562 | 11.0 | 3.0† |

*BMI*, Body mass index; *LMD*, left main disease; *IABP*, intra-aortic balloon pump.
Missing values are not presented in the table. *$.001 < P < .05$; †$P \leq .001$.
‡Definition on the basis of specific diagnoses, such as intraoperative massive bleeding and additional grafts.

ACD