Long-Term Survival of Patients With Chronic Obstructive Pulmonary Disease Undergoing Coronary Artery Bypass Surgery

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Background—Chronic obstructive pulmonary disease (COPD) is associated with increased in-hospital mortality in patients undergoing coronary artery bypass surgery (CABG). Long-term survival is less well understood. The present study examined the effect of COPD on survival after CABG.

Methods and Results—We conducted a prospective study of 33 137 consecutive isolated CABG patients between 1992 and 2001 in northern New England. Records were linked to the National Death Index for long-term mortality data. Cox proportional hazards regression was used to calculate hazard ratios (HRs). Patients were stratified by: no comorbidities (none), COPD, COPD plus comorbidities, and other comorbidities with no COPD. There were 131 434 person years of follow-up and 5344 deaths. The overall incidence rate (deaths per 100 person years) was 4.1. By group, rates were: 2.1 (none), 4.0 (COPD alone), 5.5 (other), and 9.4 (COPD plus; log rank P=0.001). After adjustment, survival with COPD alone was worse compared with none (HR, 1.8; 95% CI, 1.6 to 2.1; P<0.001). Patients with other comorbidities compared with none had even worse survival (HR, 2.2; 95% CI, 2.1 to 2.4; P<0.001). Patients with COPD plus other comorbidities compared with none had the worst long-term survival (HR, 3.6; 95% CI, 3.3 to 3.9; P<0.001).

Conclusions—Patients with only COPD had significantly reduced long-term survival compared with patient with no comorbidities. Patients with COPD and ≥1 other comorbidity had the worst survival rate when compared with all of the other groups. (Circulation. 2006;114[suppl I]:I-430–I-434.)

Key Words: survival ■ chronic obstructive pulmonary disease ■ revascularization ■ morbidity ■ surgery

Chronic obstructive pulmonary disease (COPD) is a common comorbidity among patients undergoing coronary artery bypass graft (CABG) surgery. It is prevalent, affecting 10.7 million Americans, and was the fourth leading cause of death in 2002.1 By comparison, 13 million Americans had atherosclerotic cardiovascular disease (ASCVD), which was the leading cause of death that same year, accounting for 38% of all deaths. Both of these disease processes are closely linked to smoking; therefore, they coexist frequently.2 CABG surgery is a therapeutic mainstay for ASCVD. In 2002, 467 000 coronary artery bypass surgery (CABG) procedures were performed in the US.3 Despite the prevalence of COPD and the annual volume of cardiac surgery, the impact of COPD on long-term survival among patients with ASCVD undergoing CABG surgery is not well defined. Even at the inception of CABG surgery, it was known that COPD was a risk factor for poor outcomes. The term “pump lung” was defined by Dodrill4 in 1958. The incidence of COPD in patients having CABG surgery varies by study, ranging from 4 to 27%.5–7 Several studies have shown variable effects of COPD on CABG morbidity and mortality.8 Other studies have shown similar in-hospital mortality rates for patients with mild to moderate COPD and worse outcomes among patients with severe COPD compared with patients without COPD.9 Two studies demonstrate no increase in in-hospital mortality in patients with COPD compared with patients without COPD.10,11 More recently, 2 prospective analyses of large cardiac registries have reported increased odds of in-hospital mortality by ratios of 1.4 to 1.6 among patients with COPD compared with patients without COPD.12,13

The published literature is sparse with respect to the long-term survival of patients with COPD who undergo CABG surgery. Medalion et al14 followed 37 patients with COPD having CABG for 8.6 years and noted a survival of 65% compared with 92% in the control group. van Domburg et al15 documented a 5-year hazard ratio (HR) for mortality of...
1.9 in COPD patients having CABG. Canver et al\textsuperscript{11} noted a
decreased 5-year survival in patients with an FEV\textsubscript{1} <1 L.
DeRose et al\textsuperscript{16} looked at long-term survival of patients with
decreased LV function. At 4 years, COPD had an HR of 1.5 for
decreased survival. The goal of this current analysis was to
further examine the impact of COPD on the long-term
survival of patients undergoing isolated CABG surgery.

Methods

Patients and Setting

The Northern New England Cardiovascular Disease Study Group (NNECDSG) is a voluntary research consortium representing all of
the centers where CABG is performed in Vermont, New Hampshire,
and Maine. Since 1987, the NNECDSG has maintained a prospective
registry of all patients undergoing cardiac surgery in our region. This
study includes 33,137 consecutive patients undergoing isolated
or another significant surgical procedure with their CABG (N =780)
were excluded from this analysis.

Data Collection

Patient and procedure information was collected prospectively for all
of the patients. Data included age, sex, body mass index (BMI) BMI
\(\leq 30\), BMI 31 to 37 (obese), or BMI >37 (severe obesity), comorbid
conditions (COPD, vascular disease, diabetes with and without
sequelae, congestive heart failure, peptic ulcer disease, preoperative
dyslipidemia-dependent renal failure or preoperative creatinine \(\geq 2\), and
cancer), preoperative ejection fraction, previous CABG surgery, left
main artery stenosis, number of diseased coronary vessels, recent
myocardial infarction (MI) within 7 days, and priority at surgery.
Informed consent was obtained from all of the patients in the
NNECDSG database.

Study Measures and Outcome

COPD was defined as “documented COPD in the medical record, or
asthma requiring inhalers, theophyllines/aminophyllines, or ster-
oids.” To better understand the effect of other comorbid conditions
on patients with COPD, we further stratified the group into the
following 4 patient subgroups: (1) patients with no comorbid disease;
(2) patients with COPD alone; (3) patients with COPD and other
comorbidity; and (4) patients with other comorbid disease without
COPD.

Long-term survival data through December 2001 were obtained by
linkage to the National Death Index (US Department of Health and
Human Services). The accuracy of the National Death Index is
between 92% and 99%. Probabilistic matching was performed based
on patient name (first, middle initial, and last), social security
number, date of birth, sex, date last known alive, and state of last
known residence. The outcome measure in this study was survival in
years after CABG procedure.

Statistical Analysis

Standard descriptive statistics (proportions and \(\chi^2\) tests) were used to
describe patient and disease characteristics by subgroup. Survival
curves for the 4 patient groups were estimated using the Kaplan–
Meier method and compared with the log-rank statistic. Cox propor-
tional hazard models were used to assess the effect of COPD with or
without other comorbidity on long-term survival while controlling
for other risk factors associated with survival. HRs and 95% CIs
were calculated. Analyses were performed using Stata software
(Stata Corporation).

We had full access to the data and take responsibility for its
integrity. We have read and agree to the article as written.

Results

Prevalence of Comorbid Conditions

In this study, diabetes was the most prevalent comorbid
condition (31% of patients) followed by obesity (BMI 31 to
37; 20%), vascular disease (19%), COPD (11%), peptic ulcer
disease (7%), severe obesity (BMI >37; 6%), renal dialysis
or creatinine \(\geq 2\) (3%), and cancer (3%). Of the 33,137
patients in this study, 44% had no comorbid disease
(N=14,557). Four percent had COPD alone (N=1,260), 7%
had COPD with other comorbidity (N=2,262), and 45% had
comorbid disease but without COPD (N=15,058). Compared
with patients with no comorbid condition, patients with
COPD and/or other comorbidities were older, more often
female, more often obese, and were more likely to have a
preoperative ejection fraction <40. They were somewhat
more likely to be having a repeat CABG, to have left main
artery stenosis and 3 vessel disease, to have had a recent MI,
and to be urgent or emergent at surgery (Table 1).

Survival Outcomes

From 1992 through 2001 there were 5,344 deaths among the
33,137 patients. For all of the patients, 131,433 person years of
follow-up data were available, and the incidence rate of mortality
(deaths per 100 person years of follow-up) was 4.1
(Table 2).

COPD had a significant effect on long-term survival. When patients
with COPD were compared with patients without
COPD, the COPD patients had nearly twice the incidence of
death (7.2 deaths per 100 person years versus 3.7 deaths per
100 person years). Figure 1 shows that the Kaplan–Meier
survival curves for COPD versus no COPD patients continue
to diverge throughout 10 years of follow-up. Five-year
survival is 71% versus 85% (COPD versus no COPD), and survival by 10 years is 48% versus 66%. The curves are
significantly different by log rank test \(P<0.001\).

To better understand the role of other comorbidities both in
patients with COPD and in those without COPD, we exam-
ined 4 patient subgroups, patients with: (1) no comorbidity;
(2) COPD only; (3) COPD with other comorbidity; and (4)
other comorbidity(s) but not COPD. Again, patients
with COPD alone compared with patients without comorbid-
ities had nearly a 2-fold increase in incidence of death (4.0
versus 2.1). Other comorbidities seemed to have a more
negative effect on survival than COPD alone (5.5 deaths per
100 person years versus 4.0 deaths per 100 person years).
Finally, the patients with COPD and \(\geq 1\) other comorbidity
had the worst survival with an incidence of death of 9.4
(Table 2). Figure 2 shows the Kaplan–Meier survival curves
for all of the comorbidity subgroups. Proportions of patients
surviving by 10 years were 77% for those with no comorbidity,
64% for those with COPD alone, 37% for patients with
COPD plus other disease, and 52% for patients with non-
COPD disease. Log rank test shows these survival curves to
be significantly different \(P<0.001\).

After adjustment for other patient and disease factors, comorbidity
subgroups retain their relative risks of death compared with each other (Table 3). Compared with patients
with no comorbid disease, patients with COPD alone have an
adjusted HR of 1.8 (95% CI, 1.6 to 2.1; \(P<0.001\)) or an 80% increase in risk. Adjusted HR for patients with non-COPD
disease is 2.2 (95% CI, 2.1 to 2.4; \(P<0.001\)). The group with
COPD and \(\geq 1\) other comorbidity had the greatest risk of
death with an HR of 3.6 (95% CI, 3.3 to 3.9; \(P<0.001\)). These
HRs were adjusted for age, sex, obesity, previous CABG, preoperative ejection fraction, number of diseased vessels, and priority at surgery, and all were statistically significant.

**Discussion**

This study used a large, multicenter, regional database to examine the 10-year all-cause mortality among isolated CABG patients who had COPD with and without other comorbidities (diabetes, vascular disease, congestive heart failure, obesity, peptic ulcer disease, renal failure, and cancer). COPD has a marked effect on long-term survival in patients undergoing CABG. It is interesting to note, however, that patients with COPD alone have a lower HR for death than patients with other comorbidities (1.8 versus 2.2). Because a majority of patients who are currently undergoing CABG surgery have ≥1 of our studied comorbidities, the presence of COPD alone should not preclude surgery based on long-term survival.

If a patient has both COPD and ≥1 other comorbidity, long-term survival is markedly affected. There is nearly a 10% per year mortality in this group of patients. Their adjusted HR for death is twice that of patients with COPD alone (1.9 versus 3.6). The 10-year survival rate of 30% compared with 80% in the group without COPD and comor-

### TABLE 1. Patient and Disease Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No Comorbid Disease</th>
<th>COPD Only</th>
<th>COPD With Other Disease</th>
<th>Comorbid Disease Without COPD</th>
<th>P Value, χ²</th>
</tr>
</thead>
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<tr>
<td>No. of procedures</td>
<td>14,557</td>
<td>1,260</td>
<td>2,262</td>
<td>15,058</td>
<td></td>
</tr>
<tr>
<td>Age, (y) % by group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>12.4</td>
<td>7.9</td>
<td>4.5</td>
<td>6.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>50 to 59</td>
<td>24.4</td>
<td>21.6</td>
<td>15.3</td>
<td>19.4</td>
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<tr>
<td>60 to 69</td>
<td>32.3</td>
<td>33.3</td>
<td>35.9</td>
<td>33.0</td>
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</tr>
<tr>
<td>70 to 79</td>
<td>25.7</td>
<td>32.2</td>
<td>37.6</td>
<td>33.8</td>
<td></td>
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<tr>
<td>≥80</td>
<td>5.2</td>
<td>5.0</td>
<td>6.6</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>Sex, % female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>22.5</td>
<td>24.6</td>
<td>31.8</td>
<td>33.0</td>
<td>&lt;0.001</td>
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<td>50 to 59</td>
<td>76.1</td>
<td>75.9</td>
<td>72.5</td>
<td>70.1</td>
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<td>60 to 69</td>
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<td>18.6</td>
<td>20.2</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>70 to 79</td>
<td>4.8</td>
<td>5.6</td>
<td>7.3</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt;30</td>
<td>76.1</td>
<td>75.9</td>
<td>72.5</td>
<td>70.1</td>
<td>&lt;0.001</td>
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<tr>
<td>31 to 37 (obesity)</td>
<td>19.1</td>
<td>18.6</td>
<td>20.2</td>
<td>22.2</td>
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<tr>
<td>&gt;37 (severe obesity)</td>
<td>4.8</td>
<td>5.6</td>
<td>7.3</td>
<td>7.7</td>
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<tr>
<td>Comorbid disease, % yes</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vascular disease</td>
<td>48.1</td>
<td>33.8</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Diabetes</td>
<td>47.2</td>
<td>59.8</td>
<td>&lt;0.001</td>
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<tr>
<td>Chronic heart failure</td>
<td>38.2</td>
<td>26.5</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dialysis or creatinine ≥2</td>
<td>7.5</td>
<td>5.6</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
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<tr>
<td>Peptic ulcer</td>
<td>16.4</td>
<td>12.7</td>
<td>&lt;0.001</td>
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<tr>
<td>Cancer</td>
<td>4.0</td>
<td>4.5</td>
<td>0.328</td>
<td></td>
<td></td>
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<tr>
<td>Ejection fraction, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt;40</td>
<td>9.1</td>
<td>14.0</td>
<td>25.9</td>
<td>19.0</td>
<td>&lt;0.001</td>
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<td>40–49</td>
<td>15.5</td>
<td>20.5</td>
<td>21.7</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>50–59</td>
<td>26.3</td>
<td>26.1</td>
<td>20.7</td>
<td>23.9</td>
<td></td>
</tr>
<tr>
<td>≥60</td>
<td>49.2</td>
<td>39.5</td>
<td>31.7</td>
<td>39.3</td>
<td></td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior CABG, % yes</td>
<td>5.8</td>
<td>6.1</td>
<td>6.3</td>
<td>6.8</td>
<td>0.003</td>
</tr>
<tr>
<td>Left main ≥50, % yes</td>
<td>22.9</td>
<td>27.1</td>
<td>30.4</td>
<td>25.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No. diseased vessels, %</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>15.9</td>
<td>11.8</td>
<td>8.9</td>
<td>11.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>39.9</td>
<td>39.8</td>
<td>35.7</td>
<td>36.4</td>
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</tr>
<tr>
<td>3</td>
<td>44.2</td>
<td>48.4</td>
<td>55.4</td>
<td>52.3</td>
<td></td>
</tr>
<tr>
<td>Recent MI (≤7 days), % yes</td>
<td>11.4</td>
<td>14.4</td>
<td>15.6</td>
<td>13.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Priority at surgery, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>33.5</td>
<td>30.0</td>
<td>25.9</td>
<td>30.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urgent</td>
<td>59.5</td>
<td>61.8</td>
<td>66.4</td>
<td>63.5</td>
<td></td>
</tr>
<tr>
<td>Emergency</td>
<td>7.0</td>
<td>8.2</td>
<td>7.8</td>
<td>6.5</td>
<td></td>
</tr>
</tbody>
</table>
bidities is a striking finding. It is for these patients that long-term survival should play a role in the discussion involving the appropriateness of CABG surgery.

**Study Limitations**

There are several limitations in our study. First is the definition of COPD. Although our definition is consistent with many other published long-term studies involving patients with COPD having CABG surgery, it is fairly broad. Pulmonary function testing was not recorded in our database. This is because of the multiple institutions in our study, as well as the financial constraints of the preoperative evaluation of the CABG patient. Canver clearly showed that FEV\(_1\) of \(<1.5\) L is a significant predictor of decreased 5-year survival. As with any disease, there is a spectrum of severity in patients with COPD in our database. The patient on home oxygen with a severely depressed FEV\(_1\) is much different than the patient who is on an inhaler only. These patients both are defined as having COPD in our study. Another limitation is that we do not know the mode of death for these patients, because our study does not let one know if patients with COPD and other comorbidities died of complications of their lung disease or their cardiovascular disease.

**Comparison With Previous Studies**

Our study showed an annual incidence of death in patients with COPD undergoing CABG of 7.2% per year. Medalion et al\(^4\) studied only 37 patients for 8.6 years of follow-up with an annual incidence of death of 4%. DeRose et al\(^6\) looked only at patients with ejection fractions \(<25\%\). He documented a 32% 10-year survival in patients with COPD and decreased LV function. These data are similar to our 10-year survival in patients with COPD and other comorbidities. Our adjusted HR of 1.8 in the COPD only group (versus patients with no comorbidity) was similar to that of van Domburg et al\(^15\). His study showed an HR of 1.9 for risk of death in patients with COPD undergoing CABG.

Renzetti et al\(^7\) in 1966 looked at mortality at 4 years from COPD alone in the Veterans Administration system. These patients were only treated medically and had a 13% per year mortality. However, patients with an FEV\(_1\) of \(>1.5\) L had a mortality of 6.5% per year.

Celli et al\(^18\) recently reported a new score (body mass index, airflow obstruction, dyspnea, and exercise capacity) to predict outcomes in patients with COPD. This was not a study of outcomes from CABG surgery; however, HRs for death from all causes (HR, 1.34; 95% CI, 1.26 to 1.42; \(P<0.001\)) and death from respiratory failure, pneumonia, or pulmonary embolism (HR, 1.62; 95% CI, 1.48 to 1.77; \(P<0.001\)) were calculated. It seems that the HR for death is greater in COPD patients having CABG surgery compared with patients with COPD who do not undergo CABG surgery. The adjusted HRs for all-cause death in this study are 1.8 in patients with COPD alone and 3.6 in patients with COPD and \(\geq 1\) other comorbidity.

We also reviewed the literature to examine noninterventional and other interventional treatments of COPD patients with ASCDDVD. There did not seem to be any literature examining the medical treatment of patients with COPD and ASCVD. But recently, an article published by Selvaraj et al\(^9\) reported that COPD was a predictor of mortality in patients undergoing percutaneous coronary intervention. Their study showed a similar survival at 5 years.

**Implications**

This study carries significant long-term implications for the patient with COPD undergoing surgical revascularization. In our study, 10.6% of patients undergoing CABG surgery have

![Figure 1](image1.png) Survival among isolated CABG surgery patients with or without COPD.

![Figure 2](image2.png) Survival among isolated CABG surgery patients by COPD and other comorbid conditions.
TABLE 3. Adjusted Hazard Ratios by Patient Subgroup

<table>
<thead>
<tr>
<th>Preoperative Comorbidity</th>
<th>Adjusted HR</th>
<th>95% CI</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No comorbidity (reference)</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD only</td>
<td>1.8</td>
<td>1.6 to 2.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other comorbidity*</td>
<td>2.2</td>
<td>2.1 to 2.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>COPD and other comorbidity*</td>
<td>3.6</td>
<td>3.3 to 3.9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Other comorbid conditions include: diabetes, vascular disease, dialysis and creatinine ≥2, peptic ulcer, cancer, and congestive heart failure.

COPD as a comorbidity, and 64% of these patients have ≥1 other comorbidity that significantly affects long-term survival. In a medical and surgical climate that is increasing complex, the ability of cardiac surgeons to accurately provide an estimate of long-term survival in patients with COPD undergoing CABG will be extremely valuable.

Conclusions

This study involved 33,137 patients undergoing coronary artery bypass surgery in Vermont, New Hampshire, and Maine. COPD was present in 10.6% of the study group. The annual incidence rate of mortality in patients with COPD was 7.2 deaths per 100 person years of follow-up compared with 3.7 deaths per 100 person years of follow-up in patients without COPD. The presence of COPD and ≥1 other comorbidity significantly reduced the 10-year survival. In COPD patients with ≥1 other comorbidity, the 10-year survival was 30%, and the incidence rate of death was 9.4 deaths per 100 person years of follow-up.

**Source of Funding**
This study was funded by the member centers of the Northern New England Cardiovascular Disease Study Group.

**Disclosures**
None.

**References**
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Circulation. 2006;114:I-430-I-434
doi: 10.1161/CIRCULATIONAHA.105.000943
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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