Queuing for Coronary Angiography During Severe Supply-Demand Mismatch in a US Public Hospital
Analysis of a Waiting List Registry

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IN RECENT YEARS A DEBATE HAS BEEN waged over the problems of escalating costs and increasingly limited access to medical care in the United States.1-3 As Americans consider health care system reform and restricting access to health care, experiences from countries with universal access policies and national health care systems have come under scrutiny. An integral component of most national health care systems is the use of waiting lists for non-urgent medical care and procedures.1-3

In this setting, the care of patients with cardiovascular diseases is of particular concern because adverse cardiac events and excess deaths have been increasingly reported during waits for either percutaneous transluminal coronary angioplasty (PTCA) or coronary artery bypass grafting.4-10

For editorial comment see p 184.

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revascularization techniques. Al-
though the existence of waiting lists for 
CA in different non-US health care del-
ivery and/or financing systems has been 
reported, it is generally accepted that 
US hospitals provide the shortest waits 
for invasive cardiovascular proce-
dures. Importantly, the most cited 
study on this subject reported data 
generated by the response of physi-
cians to hypothetical case scenarios and 
did not consider practical issues such 
as access to health care. As the num-
ber of Americans lacking health insur-
ance increases—to more than 41 mil-
lion in recent surveys—it is likely that 
a sizable proportion of the US popu-
lation may experience difficulty in ac-
cessing health care and delays in re-
ceiving medical services. This prob-
lem has been exacerbated as de-
clining reimbursement rates and mar-
ket forces have led to an increasing 
inability of private hospitals to cross-
subsidize charity care for the underin-
sured and uninsured. More so than 
ever before in the United States, large 
numbers of patients who were previ-
ously cared for in private hospitals are 
being diverted to public hospitals. These 
have become increasingly crowded, 
leading to a de facto need to ration care. 
The University of Texas Medical 
Branch (UTMB) at Galveston is a US 
public teaching hospital with 1236 li-
censed beds that serves as a tertiary re-
feral center for patients from 231 of 
Texas’ 254 counties. Uninsured pa-
tients represent 23% of UTMB’s admis-
sions and 43% of outpatient visits 
(UTMB Healthcare Financial Manage-
ment Office, unpublished data, fiscal 
year 1997). The high volume of pa-
tients seeking care at UTMB has taxed 
resources available to provide health 
services. In the years 1993-1994, an un-
precedented influx of patients re-
ferrred to UTMB for CA overwhelmed 
the capability of the cardiac catheter-
zation laboratory and a waiting list for 
nonurgent procedures had to be estab-
lished. The present study describes the 
occurrence of death, nonfatal myocar-
dial infarction (MI), and cardiac-
related hospitalizations among these pa-
tients. The clinical importance of this 
study is that objective data on the risk of 
adverse events in patients awaiting 
elective CA are limited, and none are 
available from a US population. 

METHODS 

Patient Population 
The observational cohort was com-
pared of 381 adult outpatients placed 
on a waiting list for CA. Patient queu-
ing was based on referral date. Pa-
tients not eligible for the waiting list 
were those with (1) recent MI (<30 
 days from symptom onset), (2) poten-
tially life-threatening diseases of the 
ascending aorta (aneurysm or dissec-
tion), and (3) modified Canadian 
Cardiovascular Society (CCS) angina 
classes IVb or IVc. To accurately de-
scribe the medical consequences of pro-
longed waits on cardiovascular mor-
bidity and mortality, we excluded 
patients with a short life expectancy due 
to other illnesses such as cancer or se-
vere pulmonary, hepatic, or renal dis-
ease. The study was approved by the 
UTMB institutional review board. 

Clinical Data 
At the time of referral, all patients were 
entered into a registry consisting of a 
modular database, which included de-
emonic, clinical, and insurance data. 
Noninvasive stress tests included 
treadmill exercise-electrocardiogram 
(ECG) and exercise or pharmacologic 
stress imaging (thallium scintigraphy 
or echocardiography). A positive exer-
cise-ECG result was defined as a 0.1 mV 
or greater horizontal or downsloping 
ST-segment depression in a lead with 
a normal baseline ST segment or typi-
cal angina. A strongly positive result was 
defined as an early (<3 minute) or 
striking (≥2 mV) ST depression, a drop 
in systolic blood pressure of 20 mm Hg 
or more during exercise, or the persist-
ence of ST depression longer than 6 
minutes after exercise. A positive 
nuclear imaging study result was de-
ined as a reversible thallium perfu-
sion defect in 2 or more contiguous 
zones or abnormal distribution associ-
ated with increased lung uptake in the 
absence of severely depressed resting 
left ventricular function. A positive 
stress echocardiography result was de-
ined as the development of stress-
induced, new, or worsening regional 
wall motion abnormalities in 2 or more 
contiguous segments. 

Clinical data, symptom status, and 
stress test results were evaluated in com-
bination to determine whether a pa-
tient met appropriate indications for CA. 
Appropriateness was rated according to 
the classification proposed by the Ameri-
can College of Cardiology and Ameri-
Can Heart Association (ACC/AHA). 

Significant coronary artery disease 
(CAD) was defined as at least 50% lu-
men diameter narrowing of a major epi-
cardial coronary artery or its major 
branches. In classifying the number 
of diseased vessels, a left main coronary 
artery stenosis was regarded as equiva-
 lent to stenosis in both the left ante-
rior descending and the left circum-
flex arteries. 

Follow-up and Definition 
of Adverse Events 
Patients were scheduled for CA accord-
ing to their position on the waiting list. 
A common method for filling unex-
pected cancellations in the catheter-
zation laboratory was to call a waiting list 
patient for the next day. If the patient 
was unable to come in, the available 
opening was offered to the next patient on 
the list. We used chart abstraction to 
obtain information concerning the fre-
quency of outpatient visits, prescrip-
tion changes, and hospitalizations, 
including diagnosis and length of stay. 
This evaluation included not only the 
UTMB hospitals but all hospitals to 
which patients were admitted during 
follow-up. 

For study purposes, follow-up was 
considered complete at the time of CA 
or at the time of an adverse event, if 
such event occurred before perfo-
rance of CA at the UTMB or another 
hospital. Adverse events were as fol-
lows: (1) cardiac death (defined clini-
cally as fatal MI, documented arrhyth-
mic death, death related to heart failure, 
or sudden death without a noncardiac
cause); (2) acute MI (defined as chest pain ≥20 minutes in duration and a rise in serum cardiac enzyme levels to at least twice the upper limit of normal, or the appearance of new pathologic Q waves); and (3) need for emergency or urgent hospital admission due to unstable angina (defined as accelerating or new-onset angina at rest or on exertion in patients who either have new ST segment–T wave changes, or in patients without clear ECG changes but with a history of CAD documented by angiography or noninvasive stress tests) or worsening heart failure (signs or symptoms of congestion or low cardiac output believed to be secondary to cardiac dysfunction).

Statistical Analyses
Data are expressed as mean (SD) or percentages, where appropriate. Waiting times, because of their highly skewed distribution, are presented as medians with 25th and 75th quartiles. To compare differences between groups for continuous and categorical data, t tests and χ² tests with Yates correction, respectively, were used. Waiting times were compared using the Mann-Whitney U test. The probabilities of events were estimated with the Kaplan-Meier method. Individual and joint associations of demographic and clinical variables to adverse events were estimated using Cox proportional hazard regression analysis. The proportional hazards assumption was verified by plotting the observed and predicted values for the outcome over the range of each predictor. As a measure of the strength of the association between each predictor and the outcome variable, univariate crude odds ratios (ORs) and multivariate adjusted ORs were computed, with respective 95% confidence intervals (CIs). Given the limited number of events, only the univariate correlates with associated P≤.10 values were entered into multivariate analysis to minimize the risk of model overfitting. The likelihood ratio χ² value was used as an indicator of the overall fit of the multivariate model. Internal stability of risk estimates was validated via bootstrap procedures. Missing data were analyzed using the pairwise deletion method. For variables with more than 10% of data unavailable, the potential for a systematic bias in risk estimates resulting from a “hidden” nonrandom distribution of the missing data was controlled by varying their pattern across the correlation matrix of parameter estimates iterated using the Newton-Raphson method. For all tests, a 2-sided P<.05 was regarded significant.

RESULTS
Patient Outcomes
Follow-up data were available for all 381 patients on the waiting list, including 66 (17%) who were dropped from the list for the following reasons: CA canceled by the referring physician (n = 22), declined the study (n = 6), or underwent CA in another hospital (n = 38).

During a mean (SD) follow-up of 8.4 (6.5) months, 36 patients (9.4%) experienced adverse events, including 6 deaths (1.6%), 4 MIs (1.0%), and 26 unplanned hospitalizations (6.8%) for heart failure (n = 5) or unstable angina (n = 21). The occurrence of unstable angina in these 21 patients accounted for 58% of all adverse events. Of the total 36 adverse events, 4 (2 deaths, 1 MI, and 1 hospitalization for heart failure) occurred in the 66 patients dropped from the waiting list.

The temporal distribution of the 36 adverse events is shown as Kaplan-Meier event-free survival curves (FIGURE 1). The probability of events was minimal in the first 2 weeks and increased steadily between weeks 3 and 13. At 3 months, event-free rates for death, MI, and hospitalization were 98%, 99%, and 92%, respectively. Freedom from all adverse events at 3 months was 89%.

Clinical Features
TABLE 1 shows the demographic and clinical characteristics for all patients and for patients grouped according to the occurrence of adverse events. Patients experiencing adverse events had a significantly higher frequency of cigarette smoking, more than 2 cardiac risk factors, and prior PTCA. A combination of 2 to 3 anti-ischemic drugs was given to 67% of the patients with events vs 39% of those without events (P = .001). There were no significant differences in the frequency of outpatient visits and prescription changes during follow-up between patients with and without adverse events.

Diagnostic categories, presenting symptoms, stress test results, and ACC/AHA Class of indications for CA are shown in TABLE 2. Compared with the event-free group, patients with adverse events more frequently had a history of known CAD, CCS angina class III or IVa, and positive stress test results. Furthermore, the percentage of strongly positive exercise-ECG or positive stress imaging results was significantly higher in patients with events than in those without (P = .001). Patients with and without events differed significantly in the rate of ACC/AHA class I (P = .01) and class III (P = .03) indications for CA.

Predictors of Adverse Events
Cox regression analysis of the explanatory variables listed in Tables 1 and 2 identified 7 univariate correlates of adverse events with P≤.10 (FIGURE 2). A multivariate model that included all these univariate correlates provided significant ability to predict adverse events (χ² likelihood ratio = 17.76, P = .001). However, the only individually significant predictors of events in this model were a strongly positive exercise-ECG or positive stress imaging result at referral (adjusted OR, 2.32; 95% CI, 1.22-4.16; P = .01) and use of 2 to 3 anti-ischemic medications (adjusted OR, 1.98; 95% CI, 1.19-3.96; P = .04).

Angiographic Findings, Waiting Time, and Hospital Stay
Of 381 patients placed on the waiting list, 311 underwent CA at UTMB (4 died before the scheduled CA and 66 were removed from the waiting list). Of the 311 patients, 283 (91%) had un-
eventful waits, whereas 28 (9%) experienced adverse events before the scheduled CA. Overall, 64% had significant CAD. Patients with events had a significantly higher prevalence of CAD ($P < .001$) and more frequently required revascularization ($P < .001$), predominantly coronary artery bypass grafts (Table 3).

Overall, 8% of the patients underwent CA within 2 weeks of referral, 44% waited 2 to 6 weeks, 32% waited 6 weeks to 3 months, and 16% had waiting times longer than 3 months. Waiting time and length of hospital stay are reported in Table 4. Patients who experienced adverse events had a significantly shorter waiting time vs patients without adverse events ($P = .01$). However, the length of hospital stay increased significantly for patients with adverse events ($P = .001$). To determine whether differences in demographics and clinical characteristics influenced the length of wait for CA and the duration of hospital stay, we stratified patients according to selected variables (Table 4). Age, sex, race, and symptom status were not different for patients with longer waiting times. Longer delays were observed among Medicaid-insured and uninsured patients compared with those privately insured ($P < .001$), but length of hospital stay was similar across insurance groups.

To clarify reasons for longer waiting times for the Medicaid-insured and uninsured patients, we calculated the percentages of patients who rescheduled CA or refused a next-day opening and of those who lived farther than 50 miles from the hospital. Only 11% of the privately insured patients were unable to make the appointments vs 38% of the Medicaid-insured and uninsured patients ($P < .001$). In addition, 40% of the Medicaid and uninsured patients lived farther than 50 miles from the hospital, whereas none of the privately insured patients did ($P < .001$).

### COMMENT

The present study is the first to provide objective data on morbidity and mortality in a US population awaiting elective CA. Our experience suggests that delaying CA places patients at some risk of adverse cardiac events, longer hospital stays, and, potentially, a worse prognosis.

An important finding is that a 1- to 2-week wait for CA confers minimal
risk, but that there is a progressive increase in the probability of adverse events between 3 and 13 weeks. Thus, waits longer than 2 weeks should be avoided, particularly for patients with strong indications for CA (ACC/AHA class I, representing 69% of those with adverse events in our population). In particular, the need for emergent or urgent hospitalization accounted for most of the adverse events, whereas the rates of death (1.6%) and MI (1.0%) were low. However, these rates are approximately 10 times those associated with cardiac catheterization (mortality, 0.11%; MI rate, 0.06%), emphasizing the importance of potentially preventable deaths or MIs among patients waiting for CA.

The risks outlined here are similar to other reports in the literature. In a study from Manitoba,14 after a mean wait for CA of 4.2 weeks, cardiac arrest, acute MI, and death occurred in 0.5%, 0.9%, and 0.4% of the patients, respectively, with a 3.7% rate of emergency admissions. In a second-opinion trial among patients recommended for CA for whom the procedure was deferred, annual rates of cardiac death and MI were 1.1% and 2.7%, respectively, during a 3.7% rate of emergency admissions. In a second-opinion trial among patients recommended for CA for whom the procedure was deferred, annual rates of cardiac death and MI were 1.1% and 2.7%, respectively, during a nearly 4-year follow-up.29 In addition, 21% of the patients had a cardiac hospitalization and 32% had aggravation of angina. The rates of adverse events while waiting for CA in our study and others are strikingly similar to those observed in patients awaiting coronary revascularization. Mortality rates of 0.4% to 2.2% have been reported in coronary artery bypass graft candidates after mean waiting times of 17 to 98 days,4,9 and adverse coronary events may occur in 23% of patients awaiting routine PTCA.10

It is significant that development of unstable angina accounted for 58% of the adverse events in our population because this diagnosis has a negative prognosis even if revascularization is performed.10,31 In fact, although the technical success of percutaneous interventions in unstable angina is similar to that for stable angina, the incidence of periprocedural complications as well as restenosis is higher.30 In addition, emergency surgical intervention in refractory unstable angina is accompanied by increased operative mortality rates.31

We investigated whether characteristics predictive for long-term prognosis in patients without overt CAD or with stable ischemic heart disease could also be used to identify patients at risk among those awaiting CA.32,33 That patients taking multiple anti-ischemic medications had an increased risk of short-term adverse events is particularly interesting because it contradicts the belief held by many investigators that medical therapy and revascularization are equally safe in patients with stable angina and nonlimiting symptoms.34,35 Furthermore, close medical follow-up did not prevent adverse events: there was no significant difference in the intensity of outpatient follow-up between the 2 groups. In our population, the need for multiple drugs most likely identified patients with more severe or diffuse underlying CAD. Indeed, rapid progression of preexist-

### Table 1. Demographic and Clinical Characteristics of Patients on a Waiting List for Coronary Angiography*

<table>
<thead>
<tr>
<th></th>
<th>All Patients (N = 381)</th>
<th>With Events (n = 36)</th>
<th>Without Events (n = 345)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>55 (12)</td>
<td>55 (11)</td>
<td>54 (10)</td>
<td>.57</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>233 (61)</td>
<td>18 (50)</td>
<td>215 (62)</td>
<td>.20</td>
</tr>
<tr>
<td>African American</td>
<td>88 (23)</td>
<td>9 (25)</td>
<td>79 (23)</td>
<td>.93</td>
</tr>
<tr>
<td>Hispanic</td>
<td>39 (10)</td>
<td>8 (22)</td>
<td>31 (9)</td>
<td>.02</td>
</tr>
<tr>
<td>Asian</td>
<td>21 (6)</td>
<td>1 (3)</td>
<td>20 (6)</td>
<td>.71</td>
</tr>
<tr>
<td>Insurance‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>134 (35)</td>
<td>9 (25)</td>
<td>125 (36)</td>
<td>.24</td>
</tr>
<tr>
<td>Medicaid</td>
<td>55 (15)</td>
<td>6 (17)</td>
<td>49 (14)</td>
<td>.87</td>
</tr>
<tr>
<td>Uninsured</td>
<td>192 (50)</td>
<td>21 (58)</td>
<td>171 (50)</td>
<td>.40</td>
</tr>
<tr>
<td>Cardiac risk factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>240 (63)</td>
<td>20 (56)</td>
<td>220 (64)</td>
<td>.42</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>98 (26)</td>
<td>10 (28)</td>
<td>88 (26)</td>
<td>.92</td>
</tr>
<tr>
<td>Cholesterol &gt;5.17 mmol/L (200 mg/dL)</td>
<td>91 (24)</td>
<td>8 (22)</td>
<td>83 (24)</td>
<td>.96</td>
</tr>
<tr>
<td>Cigarette smoking</td>
<td>145 (38)</td>
<td>20 (56)</td>
<td>125 (36)</td>
<td>.03</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>53 (14)</td>
<td>6 (17)</td>
<td>47 (14)</td>
<td>.80</td>
</tr>
<tr>
<td>&gt;2 Risk factors</td>
<td>178 (47)</td>
<td>23 (64)</td>
<td>155 (45)</td>
<td>.03</td>
</tr>
<tr>
<td>Cardiac history</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous MI</td>
<td>111 (29)</td>
<td>11 (30)</td>
<td>100 (29)</td>
<td>.99</td>
</tr>
<tr>
<td>Previous PTCA</td>
<td>40 (10)</td>
<td>9 (25)</td>
<td>31 (9)</td>
<td>.02</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>34 (9)</td>
<td>3 (8)</td>
<td>31 (9)</td>
<td>.85</td>
</tr>
<tr>
<td>Anti-ischemic medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β-Blockers</td>
<td>162 (42)</td>
<td>19 (53)</td>
<td>143 (41)</td>
<td>.25</td>
</tr>
<tr>
<td>Long-acting nitrates</td>
<td>199 (52)</td>
<td>24 (67)</td>
<td>175 (51)</td>
<td>.09</td>
</tr>
<tr>
<td>Calcium antagonists</td>
<td>131 (34)</td>
<td>17 (47)</td>
<td>114 (33)</td>
<td>.12</td>
</tr>
<tr>
<td>2-3 Anti-ischemic medications used</td>
<td>160 (42)</td>
<td>24 (67)</td>
<td>136 (39)</td>
<td>.001</td>
</tr>
<tr>
<td>Prescription changes during follow-up‡</td>
<td>50 (13)</td>
<td>2 (6)</td>
<td>48 (14)</td>
<td>.15</td>
</tr>
<tr>
<td>No. of outpatient visits per month of follow-up, mean (SD)</td>
<td>1.2 (0.9)</td>
<td>1.3 (0.7)</td>
<td>1.1 (1.0)</td>
<td>.24</td>
</tr>
</tbody>
</table>

*Data are presented as number (percentage) of patients, unless otherwise indicated. CAD indicates coronary artery disease; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; and CABG, coronary artery bypass grafting.
†Privately insured patients were those having either traditional indemnity insurance “fee for service,” or enrolled in preferred provider or health maintenance organizations and individual practice associations, and those covered by Medicare. Medicaid patients were those enrolled in state or federal programs for low-income individuals. Uninsured patients either had “no charge” or “self-pay” listed as their primary source of payment.
‡Prescription changes include addition or withdrawal of anti-ischemic drugs due to lack of efficacy or adverse effects.
ing stenoses leading to acute coronary events may occur despite combined antianginal treatment, as demonstrated by a study of medically stable patients placed on a waiting list for routine PTCA.\textsuperscript{36}

Our findings that a strongly positive exercise-ECG or positive stress imaging result constitutes an independent risk of early cardiac events suggests that a strategy of objectively documenting the degree of inducible ischemia is not only useful for posing an appropriate indication for CA but also for identifying patients in whom CA can be safely deferred and those requiring prompt invasive evaluation.

To examine reasons for long waits in our registry, we analyzed several variables that have been shown to be relevant to the delivery, quality, and outcome of health care.\textsuperscript{17-20} Our finding of a disparity in waiting times between Medicaid-insured and uninsured patients and those privately insured raises important issues of access to health care. The high percentage of uninsured patients in our study sample is representative of Texas demographics as a whole, including large num-

### Table 2. Indications, Presenting Symptoms, and Noninvasive Stress Test Results of Patients on a Waiting List for Coronary Angiography*

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>All Patients <em>(N = 381)</em></th>
<th>With Events <em>(n = 36)</em></th>
<th>Without Events <em>(n = 345)</em></th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected CAD</td>
<td>144 (38)</td>
<td>10 (27)</td>
<td>134 (39)</td>
<td>.26</td>
</tr>
<tr>
<td>Known CAD</td>
<td>145 (38)</td>
<td>20 (55)</td>
<td>125 (36)</td>
<td>.03</td>
</tr>
<tr>
<td>Heart failure</td>
<td>45 (12)</td>
<td>4 (11)</td>
<td>41 (12)</td>
<td>.89</td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>47 (12)</td>
<td>2 (6)</td>
<td>45 (13)</td>
<td>.30</td>
</tr>
<tr>
<td>Severity of angina: Asymptomatic</td>
<td>80 (21)</td>
<td>7 (19)</td>
<td>73 (21)</td>
<td>.97</td>
</tr>
<tr>
<td>CCs class I-II</td>
<td>211 (55)</td>
<td>14 (39)</td>
<td>197 (57)</td>
<td>.06</td>
</tr>
<tr>
<td>CCS class II-IVa</td>
<td>90 (24)</td>
<td>15 (42)</td>
<td>75 (22)</td>
<td>.01</td>
</tr>
<tr>
<td>Ejection fraction &lt;40%†</td>
<td>57 (24)</td>
<td>8 (22)</td>
<td>49 (14)</td>
<td>.29</td>
</tr>
<tr>
<td>Noninvasive stress test result‡</td>
<td>183 (82)</td>
<td>25 (69)</td>
<td>158 (46)</td>
<td>.01</td>
</tr>
<tr>
<td>Strongly positive exercise ECG or positive stress imaging</td>
<td>105 (47)</td>
<td>23 (64)</td>
<td>82 (24)</td>
<td>.001</td>
</tr>
</tbody>
</table>

*Data are presented as number (percentage) of patients. CAD indicates coronary artery disease; CCS, Canadian Cardiovascular Society angina classification\textsuperscript{26}; ECG, electrocardiogram; CA, coronary angiography; ACC, American College of Cardiology; and AHA, American Heart Association.

†Ejection fraction, assessed by echocardiography or nuclear ventriculography, was available in 237 patients (62%).

‡Noninvasive stress tests (see “Methods”) were available in 222 patients (58%).

§Class I indicates conditions for which there is general agreement that CA is justified; class II indicates conditions for which CA may be frequently performed but there is divergence of opinion regarding its usefulness; and class III is when there is general agreement that the use of CA is not justified and in some patients may be harmful (ie, risks outweigh benefits).\textsuperscript{27}

### Figure 2. Univariate Crude Odds Ratios for Factors Influencing the Risk of Adverse Cardiac Events in 381 Patients Placed on a Waiting List for Coronary Angiography

The error bars represent 95% confidence intervals, with relative minimum and maximum limits indicated by numbers in parentheses. ACC indicates American College of Cardiology; ECG, electrocardiogram; AHA, American Heart Association; CA, coronary angiography; and CCS, Canadian Cardiovascular Society angina classification.\textsuperscript{24}
bers of African American and Hispanic individuals, who have high rates of noncoverage.\textsuperscript{16,18} Additionally, Texas has relatively restrictive Medicaid programs, so that low-income, working individuals are less likely to qualify for federally funded medical coverage than they are in other states.\textsuperscript{16} Since health care services at UTMB are offered regardless of ability to pay, it is unlikely that cost-containment policies encouraging lower levels of resource utilization for uninsured patients adversely affected the waiting time for CA. Because Medicaid-insured and uninsured patients had to be called more often than privately insured patients to schedule CA and were more likely to live farther than 50 miles from the hospital, we speculate that factors such as conflicts with work schedules, child care responsibilities, and limited ability to afford transportation to access distant medical care may have contributed to the longer delays for this group.

Some limitations of our study merit discussion. The interval between referral and performance of CA was not constant for all patients, but varied depending on the dynamics of the waiting list, which were, in turn, determined by the occurrence of clinical events, bed availability, and other practical issues. Therefore, some caution is recommended in interpreting the impact of the length of time on the waiting list because the selection process itself may have influenced outcome.

While our study included some patients who underwent CA for other cardiac disease, our population was predominantly composed of patients evaluated for known or suspected CAD. Therefore, our findings probably can be generalized to the vast majority of patients referred for elective CA. Whether the results from this single tertiary public hospital can be extrapolated to the US population in general is unknown.

Physicians would prefer not to delay needed medical and surgical services. However, our experience underscores the problem of limited access and delays in the delivery of health services for a population largely composed of uninsured patients in the setting of a US public hospital. Apart from the effects on patients of persisting symptoms and the anxiety associated with waiting,\textsuperscript{12,37} our results suggest that destabilization of patients’ clinical conditions while awaiting CA may lead to unplanned hospital admissions and longer hospital stays (with their own costs to patients and society), expedited procedures (bumping other patients down the waiting list), and increased risks in the context of acute conditions such as MI, unstable angina, or worsening heart failure. The issue of consecutive delays for both CA and revascularization also should be considered. The benefits of PTCA and coronary artery bypass graft in reducing symptoms, improving quality of life, and extending the life expectancy of defined patient groups are well known,\textsuperscript{33,36,39} and a long waiting time before receiving definitive treatment may result in a reduced probability of overall benefit.

Identifying patients at high and low risk by using clinical predictors, along with monitoring for excessive waits and other inequities, could help in devising fair and practical solutions for allowing the health care system to pro-

### Table 3. Angiographic Findings and Subsequent Revascularization Procedures in the 311 Waiting List Patients Who Underwent Coronary Angiography Grouped According to the Occurrence of Adverse Cardiac Events\textsuperscript{a}

<table>
<thead>
<tr>
<th>With Events (n = 28)</th>
<th>Without Events (n = 283)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of CAD</td>
<td>27 (96)</td>
<td>171 (60)</td>
</tr>
<tr>
<td>Single-vessel disease</td>
<td>8 (29)</td>
<td>62 (22)</td>
</tr>
<tr>
<td>Multivessel disease</td>
<td>19 (68)</td>
<td>109 (39)</td>
</tr>
<tr>
<td>Total revascularizations</td>
<td>26 (93)</td>
<td>149 (53)</td>
</tr>
<tr>
<td>PTCA</td>
<td>9 (32)</td>
<td>64 (23)</td>
</tr>
<tr>
<td>CABG</td>
<td>17 (61)</td>
<td>85 (30)</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Data are presented as number (percentage) of patients. CAD indicates coronary artery disease; PTCA, percutaneous transluminal coronary angioplasty; and CABG, coronary artery bypass grafting.

### Table 4. Waiting Time and Length of Hospital Stay in the 311 Waiting List Patients Who Underwent Coronary Angiography Stratified According to Selected Demographic and Clinical Features\textsuperscript{b,c}

<table>
<thead>
<tr>
<th>Waiting Time, d</th>
<th>25th Quartile</th>
<th>Median</th>
<th>75th Quartile</th>
<th>P Value</th>
<th>Hospital Stay, d, Mean (SD)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>30</td>
<td>41</td>
<td>78</td>
<td>NA</td>
<td>1.8 (2.0)</td>
<td>NA</td>
</tr>
<tr>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With events</td>
<td>17</td>
<td>31</td>
<td>47</td>
<td>.01</td>
<td>6.2 (4.3)</td>
<td>.001</td>
</tr>
<tr>
<td>Without events</td>
<td>31</td>
<td>41</td>
<td>83</td>
<td></td>
<td>1.3 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;65</td>
<td>29</td>
<td>41</td>
<td>76</td>
<td>.64</td>
<td>1.7 (1.8)</td>
<td>.68</td>
</tr>
<tr>
<td>≤65</td>
<td>27</td>
<td>40</td>
<td>79</td>
<td></td>
<td>1.6 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>31</td>
<td>40</td>
<td>78</td>
<td>.73</td>
<td>1.5 (1.1)</td>
<td>.46</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td>40</td>
<td>80</td>
<td></td>
<td>1.7 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>25</td>
<td>39</td>
<td>75</td>
<td>.59</td>
<td>1.4 (2.2)</td>
<td>.72</td>
</tr>
<tr>
<td>Other</td>
<td>32</td>
<td>41</td>
<td>80</td>
<td></td>
<td>1.5 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>16</td>
<td>26</td>
<td>31</td>
<td>&lt;.001</td>
<td>1.9 (1.4)</td>
<td>.39</td>
</tr>
<tr>
<td>Medicaid/uninsured</td>
<td>29</td>
<td>49</td>
<td>80</td>
<td></td>
<td>1.7 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Angina severity\textsuperscript{d}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCS class I-II</td>
<td>30</td>
<td>41</td>
<td>79</td>
<td>.81</td>
<td>2.0 (0.9)</td>
<td>.22</td>
</tr>
<tr>
<td>CCS class III-Va</td>
<td>27</td>
<td>41</td>
<td>81</td>
<td></td>
<td>1.7 (1.8)</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{b}Waiting time denotes the time interval between referral and performance of coronary angiography. NA indicates not applicable.

\textsuperscript{c}Definitions are provided in the second footnote to Table 1.

\textsuperscript{d}CCS indicates Canadian Cardiovascular Society angina classification.\textsuperscript{46}
provide flexibility for accommodating periodic surges in caseload, ultimately minimizing patient jeopardy. In conformity with the recommendation to collect outcome data on a regular basis, endorsed by the 23rd Bethesda Conference on access to cardiovascular care,1 our experience suggests that in any health care system, there should be an ongoing triage of patients on waiting lists, with those at greatest risk being moved to the head of the line.

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**REFERENCES**


