Unstable Angina and Non–ST-Elevation Myocardial Infarction

Initial Antithrombotic Therapy and Early Invasive Strategy

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Case: Presentation: A 59-year-old woman with a history of prior coronary artery bypass surgery 8 years ago presents with ongoing chest discomfort for 45 minutes that has been unrelieved with 3 sublingual nitroglycerin tablets. Past medical history is notable for diabetes controlled with oral medication, long-standing hypertension, and a family history of coronary disease. She has a history of a non–ST-elevation myocardial infarction (NSTEMI) with preserved ejection fraction. Her baseline medications include aspirin, a β-blocker, and an angiotensin-converting enzyme (ACE) inhibitor. In the ambulance, she received additional sublingual nitroglycerin and had resolution of her pain. In the emergency department, an ECG showed 1 mm of ST-segment depression anteriorly. Initial creatinine kinase-MB and troponin measurements were negative (ie, below the upper reference limit).

Initial Assessment
The initial evaluation of patients with unstable angina and NSTEMI (UA/NSTEMI) begins with assessment of the likelihood that the presenting symptoms represent ischemia. According to the American College of Cardiology/American Heart Association (ACC/AHA) guidelines for UA/NSTEMI, several factors are associated with a high likelihood that symptoms represent ischemic acute coronary syndrome. Most important among them are chest or left arm pain or discomfort that reproduces the patient’s prior documented angina, a known history of coronary disease or MI, evidence of heart failure on physical examination, ST-segment or T-wave changes on ECG, or elevated cardiac biomarkers. An intermediate likelihood can be predicted by age over 70 years, male sex, and diabetes or by evidence of extracardiac vascular disease on physical examination or ECG abnormalities not documented to be new. Thus, the clinical history is critical in the initial evaluation of patients with possible acute coronary syndromes to discriminate patients with true ischemic symptoms from those with non-cardiac chest pain. In our case, the patient’s history is consistent with a very high likelihood that her symptoms—chest discomfort, prior history of coronary disease, and ECG changes—represent an acute coronary syndrome.

Risk Stratification
To determine the intensity of both medical and interventional therapies, the next assessment is for the short-term risk of death or recurrent MI. Factors associated with a high risk of death or nonfatal MI are a history of accelerating symptoms in the prior 48 hours, prolonged (>20 minutes) rest pain, evidence of congestive heart failure, age over 75 years, ST-segment changes, or elevated cardiac biomarkers. Low-risk patients present without rest pain, ECG changes, or evidence of heart failure.

The ECG is very useful in risk stratifying patients in that multiple studies have shown that the presence of ST-segment depression or transient elevation is a marker of increased risk. T-wave inversion appears to add little risk, but may be useful in differentiating a patient experiencing true myocardial ischemia from one with non-cardiac chest pain.

Cardiac Biomarkers
Cardiac biomarkers are a cornerstone for evaluating and targeting therapy in...
UA/NSTEMI. Multiple studies have shown that patients with an elevated troponin level are at increased risk.\textsuperscript{1,5–7} There appears to be a direct relationship between the degree of troponin elevation and mortality.\textsuperscript{3} Interestingly, recurrent MI appears to be very high among patients with low levels of troponin elevation, and thus the rate of death or MI appears to be equally high in patients with either low or high troponin values.\textsuperscript{7} The European Society of Cardiology (ESC)/ACC consensus document on MI, as well as multiple trials in UA/NSTEMI, supports a very low cut-point for troponin elevation as a biomarker of adverse outcome in patients presenting with a clear history of ischemic symptoms.\textsuperscript{1,5–8} It should be noted however, that in patients without a clear history, troponin elevations in the absence of ischemia have been reported\textsuperscript{10} and can be caused by congestive heart failure,\textsuperscript{11} pulmonary embolism,\textsuperscript{12} or technical problems with the assay.\textsuperscript{10} Thus, in patients with an unclear history, small troponin elevations may not be diagnostic of acute coronary syndromes (ACS). In contrast, among patients with a clinical history suggestive of myocardial ischemia, troponin elevations have very strong prognostic implications of adverse outcomes.\textsuperscript{1,5–7,13–15}

Multiple studies show that troponin can be used to guide antithrombotic and interventional therapies.\textsuperscript{6,7,13–15} This was seen in trials with low molecular weight heparin (LMWH).\textsuperscript{13,14} In 4 trials of glycoprotein (GP) IIb/IIIa inhibitors, there was a 50% to 70% reduction in death or MI in troponin-positive patients receiving GP IIb/IIIa inhibitors compared with those receiving aspirin and heparin alone.\textsuperscript{6,16} In contrast, patients with a negative troponin level had no benefit from LMWH or GP IIb/IIIa inhibition as compared with aspirin and heparin.\textsuperscript{6,13,14,16} Similarly, in the Treat angina with Aggrastat and determine Costs of Therapy with Invasive or Conservative Strategies-Thrombolysis in Myocardial Infarction 18 (TACTICS-TIMI 18) study, an early invasive strategy conferred a 40% reduction in recurrent cardiac events for patients with a positive troponin (troponin T >0.01 or troponin I >0.1 ng/mL), whereas no benefit was seen for patients with a negative troponin.\textsuperscript{7,15}

It should be noted that the oral antiplatelet agents appear to have a different pattern: Both aspirin and clopidogrel benefit patients across the range of risk as predicted by baseline characteristics, including those with positive or negative biomarkers.\textsuperscript{17,18}

Among numerous other cardiac biomarkers under intensive investigation are C-reactive protein\textsuperscript{19} and B-type natriuretic peptide,\textsuperscript{20} both of which correlated with increased mortality and recurrent cardiac events in patients presenting with acute coronary syndromes. Further ongoing research will determine if therapies are differentially beneficial in patients with elevated novel markers. A multi-marker strategy is being developed to more fully define the pathophysiologic mechanisms underlying a given patient’s presentation and to further risk-stratify the patient across the axes of myocardial necrosis, inflammation, and neurohormonal activation.\textsuperscript{21}

Finally, a comprehensive risk score can be calculated. For example, the TIMI Risk Score for UA/NSTEMI is comprised of 7 factors; an increase in the number of factors correlates with an increase in the rate of recurrent cardiac events.\textsuperscript{2} Importantly, use of the TIMI Risk Score can enable identification of patients who would benefit to a higher degree from the more aggressive antithrombotic and interventional strategies.\textsuperscript{2,15,22} Thus, risk stratification is a key and integral part of the initial evaluation and management of patients with acute coronary syndromes.

**Treatment**

Initial treatment for unstable angina has evolved rapidly, with increasing emphasis on antithrombotic therapy.\textsuperscript{1,23} Initial treatment should include aspirin, which reduces events by 50% to 70% as compared with placebo (Figure 1 and Figure 2).\textsuperscript{23} On the basis of a demonstrated incremental benefit over aspirin alone,\textsuperscript{25–27} unfractionated heparin (UFH) or LMWH should be added to the medical regimen of all patients with UA/NSTEMI. Comparative trials of the LMWH enoxaparin have demonstrated its superiority over UFH in reducing recurrent cardiac events.\textsuperscript{28–29} The 2002 Updated ACC/AHA UA/NSTEMI practice guidelines noted with a class IIA recommendation that enoxaparin is the preferred antithrombin over UFH.\textsuperscript{23}

Two direct thrombin inhibitors, hirudin and bivalirudin, have been tested in patients with UA/NSTEMI with trends toward benefit, although none of the trials showed a statistically significant reduction in their primary endpoint. Thus, no direct antithrombin has as yet been approved for manage-
Although there are no randomized studies in ACS patients using quadruple antithrombotic therapy (aspirin, clopidogrel, heparin or LWMH, and “upstream” GP IIb/IIIa inhibitor) as recommended in the ACC/AHA Guidelines, there are now data available from several PCI trials, including Clopidogrel in Unstable angina to prevent Recurrent ischemic Events (CURE) trial, Clopidogrel in Unstable angina to prevent Recurrent ischemic Events During Observation (CREDO) trial. In CREDO, patients with planned or likely PCI (which included approximately two-thirds of patients with ACS) were randomized to receive a loading dose of clopidogrel (300 mg) or placebo between 3 and 24 hours before PCI. After stenting, all patients received open label clopidogrel for 28 days after stenting; after 28 days, patients in the pretreatment group continued on clopidogrel for 1 year, whereas the non-pretreatment group was treated with matching placebo. This study found no increase in bleeding in patients receiving the clopidogrel versus placebo in addition to aspirin, heparin, and GP IIb/IIIa inhibition. Similar safety observations regarding clopidogrel have been made in PCI-CURE, TARGET, and the randomized Troponin in Planned PTCA/Stent Implantation With or Without Administration of the Glycoprotein IIb/IIIa Receptor Antagonist Tirofiban (TOPSTAR) trials.33–35

The efficacy results from CREDO lend further support to both early and long-term use of clopidogrel in UA/NSTEMI patients. Pretreatment with clopidogrel led to a non-significant 19% risk reduction in events; however, patients given clopidogrel at least 6 hours before PCI had a significant 38.6% relative risk reduction in major events at 28 days ($P=0.05$) compared with no reduction with treatment less than 6 hours before PCI. This finding emphasizes the need to initiate clopidogrel as soon as possible on admission for UA/NSTEMI, before any planned catheterization and followed by possible PCI. Overall, long-term treatment (1 year) with clopidogrel plus aspirin led to a 26.9% relative reduction in death, MI, or stroke compared with post-PCI clopidogrel therapy for one month (8.5% versus 11.5% [placebo], $P=0.02$). This included a further 37.4% relative reduction in major events from day 29 to 1 year with clopidogrel ($P=0.04$). In summary, the results of PCI-CURE and CREDO support preprocedural loading with clopidogrel in those scheduled or expected to undergo PCI, showing significant benefits with or without the concomitant use of GP IIb/IIIa inhibitors. In addition, data from these trials and CURE support long-term treatment with aspirin plus clopidogrel in patients after PCI and in those with ACS.

Intravenous GP IIb/IIIa inhibitors are also beneficial in treating UA/NSTEMI.36 For “upstream” management (ie, initiating therapy when the patient first presents to the hospital), the small-molecule inhibitors eptifibatide and tirofiban clearly show benefit, whereas abciximab was of no benefit in an unselected UA/NSTEMI patient population,37 and is in fact contraindicated for patients treated with a noninvasive strategy.38

![Figure 2. Algorithm for risk stratification and treatment of patients with UA/NSTEMI.](Image 98x519 to 332x686)
Chemical pain. Although useful for ongoing pain, additional medical therapy is recommended for patients with a history of bleeding must be screened carefully, and fewer antithrombotic agents should be considered for such patients. Anti-ischemic therapy with nitrates is also recommended for patients with UA/NSTEMI. Intravenous nitrates should be prescribed for ongoing ischemic pain. Although useful for treating angina, oral nitrates do not prevent cardiac events during long-term treatment and thus can be discontinued on successful revascularization. β-Blockade remains a cornerstone of treatment. Intravenous β-blockade followed by oral β-blockade targeted to a heart rate of 50 to 60 is recommended for ongoing pain. Additional medical therapy includes ACE inhibition for long-term secondary prevention. When started early during hospitalization for UA/NSTEMI, statin therapy can be beneficial in reducing recurrent ischemic events. The wealth of data in long-term secondary prevention has elevated statin use to a class I recommendation for those with low-density lipoprotein (LDL) levels >130 and is likely relevant to those with LDL >100, as per the National Cholesterol Education Program (NCEP) III guidelines. New information from the Heart Protection Study shows benefit of simvastatin 40 mg over placebo during long-term secondary prevention regardless of baseline LDL, including patients with a baseline LDL of <100, thus suggesting that statin therapy may be indicated for patients with any evidence of coronary or vascular disease. Further review of these data and potential revision of the NCEP practice guidelines may be necessary before widespread use of statin therapy is adopted in patients with LDL <100.

Invasive Versus Conservative Strategy

Nine randomized trials have assessed the merits of an invasive strategy involving routine cardiac catheterization, with revascularization if feasible, versus a conservative strategy where angiography and revascularization are reserved for patients who have evidence of recurrent ischemia either at rest or on provocative testing. The first 3 of these trials failed to demonstrate a significant benefit, but the subsequent 6 trials (including the Fragmin and fast Revascularization during Infarction in Coronary artery disease [FRISC] II, TACTICS-TIMI 18, and Randomized Intervention Trial of unstable Angina [RITA] trials) have shown a significant benefit (Figure 3). Preliminary data from the Intracoronary Stenting with Antithrombotic Regimen COOLing-off (ISAR-COOL) study found a benefit of an immediate invasive strategy with an average time to catheterization of 2 hours compared with a delayed invasive strategy (average time to catheterization 4 days).

The benefits of the early invasive strategy were seen in intermediate- and high-risk patients, especially in those with ST-segment changes who had a positive troponin on admission. Similar findings regarding risk and degree of enhanced benefit were seen in the FRISC II trial. Accordingly, the 2002 ACC/AHA guidelines added ST-segment changes and positive troponin to the list of high-risk indicators that would lead to a class I recommendation for an early invasive strategy. An early invasive strategy is very cost-effective, with a cost of $12 739 per life year saved, even in low-risk patients.

Summary

The evaluation of patients with UA/NSTEMI begins with the clinical history, ECG testing, and measurement of cardiac biomarkers to assess (1) the likelihood of coronary disease and (2) the patient’s risk of death or recurrent cardiac events (Figure 2). Patients with
A low likelihood of having UA/NSTEMI should undergo a “diagnostic pathway” evaluation via serial ECGs, cardiac biomarkers, and early stress testing to evaluate for coronary disease. This can frequently be accomplished in an emergency department observation/checkbox pain unit. Among patients with a clinical history strongly consistent with UA/NSTEMI, those at low risk should be treated with antithrombotic therapy with aspirin, clopidogrel, and either heparin or LMWH. An early conservative strategy is adequate in low-risk patients, although an invasive strategy is equally clinically beneficial. For intermediate and high-risk patients (ST-segment changes, positive troponin, TIMI Risk Score ≥3), the above-mentioned medications plus GP IIb/IIIa inhibition (thus, 4 antithrombotic agents) are beneficial, and an early invasive strategy is preferred (Figure 1). Additional studies of the various combinations of treatments are ongoing to define further the safety of these regimens.

Case Follow-Up

The patient described above presented with ST segment changes and a TIMI risk score of 4, and her guideline-recommended treatment regimen was initiation of aspirin, clopidogrel, enoxaparin, and a small-molecule GP IIb/IIIa inhibitor, in addition to continued β-blocker and ACE inhibitor. On the morning after admission, she was referred for angiography and had a 90% left anterior descending artery stenosis that was successfully stented. She was discharged the next day receiving aspirin, clopidogrel for at least 9 months, a β-blocker, an ACE inhibitor, a statin, and an oral hypoglycemic agent.

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