Use of Atropine in Patients with Acute Myocardial Infarction and Sinus Bradycardia

By Melvin M. Scheinman, M.D., David Thoburn, and Joseph A. Abbott, M.D.

SUMMARY
Fifty-six patients with acute myocardial infarction complicated by sinus bradycardia (SB) were treated with intravenous atropine and monitored in a coronary care unit. Atropine decreased or completely abolished premature ventricular contractions (PVCs) and/or bouts of accelerated idioventricular rhythm in 27 of 31 patients (87%) and brought systemic blood pressure up to normal in 15 of 17 patients (88%) with hypotension. In addition, atropine administration was associated with improved atrioventricular conduction in 11 of 13 patients (85%) with acute inferior myocardial infarction associated with 2° or 3° atrioventricular block. Seven patients developed ten significant adverse effects: ventricular tachycardia or fibrillation in three, sustained sinus tachycardia in three, increased PVCs in three, and toxic psychosis in one. These major adverse effects correlated with either a higher initial dose of atropine (i.e., 1.0 mg as compared with the usual 0.5 or 0.6 mg) or a total cumulative dose exceeding 2.5 mg over 24 hours. Atropine is the drug of choice for management of patients with SB and hypotension and is effective in the treatment of ventricular arrhythmias as well as conduction disturbances in patients with inferior myocardial infarction. Serious adverse effects, however, preclude use of atropine without careful medical supervision.

ATROPINE has been suggested as the treatment of choice for hypotension and/or premature ventricular depolarizations (PVCs) in patients with acute myocardial infarction and bradycardia. Recent laboratory studies, however, have emphasized the possible adverse effects of atropine in the presence of acute myocardial ischemia, and several reports have extended these observations to patients with acute myocardial infarction. Although previous studies have carefully documented the incidence and mortality associated with sinus bradycardia, no detailed evaluation of the benefits and hazards of atropine therapy in patients with acute myocardial infarction under continuous electrocardiographic monitoring in a coronary care unit is available. Such an evaluation is reported here.

Materials and Methods

Data from all patients admitted to the coronary care unit at San Francisco General Hospital with the diagnosis of definite acute myocardial infarction from July, 1970, to July, 1974, were reviewed. Our criteria for the diagnosis of definite acute myocardial infarction were described in detail previously. In brief, they consist of a compatible history, evolutionary electrocardiographic changes, and characteristic changes of serum creatine phosphokinase (CPK), glutamic oxaloacetic transaminase (SGOT), and lactate dehydrogenase (LDH) levels. From July, 1973, to December, 1974, the MB fraction of the serum CPK was also used to confirm the diagnosis. All patients were under continuous electrocardiographic monitoring, including a 12 sec memory tape automatically triggered by preset alarms. All rhythm strips were inserted into the medical record.

Patients with sinus bradycardia (defined as heart rate below 60 beats/min) were included in the study. Excluded from the study were patients with sinus bradycardia occurring preterminally or appearing during or after cardiopulmonary resuscitation, patients with anterior myocardial infarction with sinus bradycardia and atrioventricular (A-Y) block because they were treated with emergency insertion of a temporary transvenous pacemaker, patients who received medications that could conceivably affect heart rate (e.g., digitalis, propranolol), or patients with known antecedent sinus bradycardia. The majority of patients received analgesics (usually morphine) before admission to the coronary care unit, and the incidence of sinus bradycardia did not differ significantly between those who received analgesics (29%) and those who did not (28%). Patients admitted to the coronary care unit were treated by house officers under the supervision of a single attending physician (M. M. Scheinman). During the study period, the unit policy was to treat all patients with acute myocardial infarction complicated by sinus bradycardia and pump failure with an initial bolus intravenous injection of at least 0.5 mg of atropine sulfate. Patients with acute myocardial infarction, sinus bradycardia, and ventricular arrhythmias were treated with either atropine or antiarrhythmic agents; the choice of drug and dose were left to the discretion of the house officer. In those patients who received atropine, the dose of drug and time intervals between doses were recorded. In addition, continuous electrocardiographic rhythm strips were obtained before and for 3 min after...
atropine administration. In the event of complications, longer rhythm strips were obtained.

The medical records of all subjects studied were reviewed and the age, sex, previous medical history, electrocardiographic localization of the site of infarction, atropine dosage, all recorded rhythm strips, and cause of death were analyzed. From a review of the rhythm strips and recordings of the systemic blood pressure, it was possible to determine maximal heart rate and changes in blood pressure and cardiac rhythm before and after administration of atropine. Development of sustained (>5 min) sinus tachycardia (defined as a heart rate above 100 beats/min) and/or ventricular arrhythmias within 3 min after atropine administration were considered major adverse effects of atropine. Minor parasympatholytic symptoms or transient (<5 min) sinus tachycardia was also noted. The appropriate clinical data were collected at the time of discharge (or death) from the coronary care unit. An IBM 360/15 computer was used for subsequent data retrieval and analysis.

Results

During the four year period, 480 patients were admitted to San Francisco General Hospital with the diagnosis of acute myocardial infarction; 106 of these patients (22%) had associated sinus bradycardia. All patients were admitted from 30 min to 13 hours after onset of symptoms with a mean delay interval of 5 ± 3.2 hours. Twenty-three patients were excluded from the study for reasons already detailed in the Methods section. Of the remaining 83 patients, 56 received intravenous atropine. The clinical data for all patients who received atropine are summarized in table 1, and heart rate response and major adverse effects of atropine are summarized in figure 1 and table 2.

Heart Rate

Heart rate increased significantly ($P < 0.01$) from $53 ± 8$ beats/min before atropine to peak rates of $85 ± 18$ beats/min after atropine. After atropine, 12 patients had transient (<5 min) sinus tachycardia (>100 beats/min) but no adverse effects. Three patients had more sustained sinus tachycardia, lasting from 5 to 18 min: a peak heart rate of 150 beats/min occurred in one (fig. 2), which subsided spontaneously, but ventricular tachycardia and fibrillation requiring external countershock developed in the other two, respectively. Three patients failed to respond to repeated doses of atropine, while five patients showed minimal increases in heart rate (see fig. 1) after one dose but responded to subsequent atropine doses.

Ventricular Arrhythmias

Atropine terminated or decreased the number of PVCs in 14 of 17 (82%) patients with frequent PVCs (>5/min). However, atropine was effective in terminating PVCs in only one of three patients with closely coupled PVCs (fig. 3). Atropine terminated 13 of 14 episodes of accelerated idioventricular rhythm (14 patients) (fig. 4). However, PVCs increased after atropine in three patients, and ventricular fibrillation developed after the sinus rate increased to 85 beats/min in one (fig. 5).

A-V Conduction

In 13 patients, sinus bradycardia was complicated by either 2° or 3° (A-V) block. In four of six patients with Mobitz I A-V block, 1:1 A-V conduction returned

Table 1

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Beneficial and Adverse Effects Associated with Administration of Atropine in Patients with Acute Myocardial Infarction and Sinus Bradycardia</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients with beneficial effects (incidence)</td>
<td>No. of patients with major adverse effects (incidence)</td>
</tr>
<tr>
<td>Decrease or abolition of ventricular arrhythmias</td>
<td>Normalization of pressure in hypotensive patients</td>
</tr>
<tr>
<td>Sustained sinus tachycardia</td>
<td>Increased number of PVCs</td>
</tr>
<tr>
<td>27/31 (87%)</td>
<td>15/17 (88%)</td>
</tr>
</tbody>
</table>

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ATROPINE IN AMI

Table 2

Relationship Between Atropine Dosing and Major Adverse Effects

<table>
<thead>
<tr>
<th>Major adverse effect</th>
<th>No. of occurrences and initial atropine dose</th>
<th>No. of occurrences and cumulative dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained sinus tachycardia</td>
<td>1* 1*</td>
<td>1</td>
</tr>
<tr>
<td>More frequent PVCs</td>
<td>1 1*</td>
<td>1</td>
</tr>
<tr>
<td>Ventricular tachycardia or fibrillation</td>
<td>2 2</td>
<td>1</td>
</tr>
<tr>
<td>Toxic psychosis</td>
<td>1 1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong> (10)</td>
<td>2 4</td>
<td>4</td>
</tr>
</tbody>
</table>

*These patients are the same subjects who developed ventricular tachycardia or fibrillation.

pari passu with the increased atrial rate after atropine. In two patients whose rhythm strips showed 3:2 and 4:3 A-V Wenckebach conduction, atrial rate increased with 2:1 and 3:2 Wenckebach conduction after atropine; ventricular rate and blood pressure also increased after atropine in these patients. Rhythm strips of seven patients showed A-V dissociation due to complete A-V block that reverted to 1:1 A-V conduction after atropine; however, sustained sinus tachycardia with 1:1 A-V conduction resulted in ventricular tachycardia in one and ventricular fibrillation in another (see above).

Systemic Blood Pressure

For the group as a whole, mean cuff systemic blood pressure rose from 107 ± 30/69 ± 18 before atropine to 127 ± 23/80 ± 18 mm Hg after atropine. In 17 patients with systemic hypotension (systolic pressure < 100 mm Hg), mean blood pressure rose significantly (P < 0.05) from 77 ± 17/43 ± 20 to 115 ± 12/69 ± 12 mm Hg. Seven of these patients had evidence of decreased systemic flow manifested by cool clammy skin and altered sensorium; these clinical manifestations were dramatically reversed within minutes after atropine. Two of the 17 patients with hypotension failed to respond to atropine but were successfully managed with low dose isoproterenol infusions.

Atropine Dose and Major Adverse Effects

Single bolus injections of atropine varied from 0.5 to 1.0 mg. Absolute or mean percent increase in heart rate did not differ significantly in patients who received 0.5 or 0.6 mg (+32 beats/min), 0.8 mg (+27 beats/min), or 1.0 mg atropine (+35 beats/min). Ten instances of major adverse effects of atropine were observed in seven of the 56 patients treated (fig. 1): sustained (>5 min) sinus tachycardia developed on three occasions, more frequent PVCs occurred in three, ventricular tachycardia or fibrillation occurred in three, and toxic psychosis developed in one. Major adverse effects occurred in two of 34 patients (5%)

![Figure 2](http://circ.ahajournals.org/)

Electrocardiographic recordings (using modified V1 or MCL1 leads) of a patient with sinus bradycardia. A) before atropine, sinus bradycardia with a heart rate of 42 beats/min. B) after administration of 1.0 mg atropine intravenously, sinus tachycardia with a peak ventricular rate of 150 beats/min developed and was sustained for 5 min without change in blood pressure or clinical status. Lidocaine infusion for treatment of ventricular quadrigeminy had been started before atropine administration.

![Figure 3](http://circ.ahajournals.org/)

Electrocardiographic recordings of a patient with sinus bradycardia associated with PVCs. A) before atropine, sinus bradycardia (80 beats/min) and coupled PVCs with the second beat of the pair interrupting the preceding T wave were present. B) after administration of 0.5 mg atropine intravenously, normal sinus rhythm with a heart rate of 63 beats/min occurred and PVCs were abolished.
who received an initial dose of 0.6 mg and four of 15
(26%) who received an initial dose of 1 mg (table 2).
All patients (four) who received greater than 2.5 mg

within 2½ hours developed major adverse effects. The
amount of atropine required for maintenance of a
ventricular rate between 70 to 100 beats/min was ex-
tremely variable: normal heart rates were achieved
after one dose of 0.5 to 1.0 mg of atropine in 27
patients, whereas multiple doses with the total dose
ranging from 1.0 to 8.0 mg were required in 29
patients. One patient received 1 mg of atropine every
6 hours for 48 hours; each dose resulted in acceler-
ation of the sinus rate and abolition of an accelerated
idioventricular rhythm.

Discussion
Atropine and Ventricular Arrhythmias
Our study confirms the effectiveness of intravenous
administration of atropine in abolishing either
sporadic PVCs and/or accelerated idioventricular
rhythms in patients with acute myocardial infarction
and sinus bradycardia. However, recent case reports
emphasized the association between development of
serious ventricular dysrhythmias and atropine ad-
ministration in patients with these disorders.9, 10, 16, 17
Moreover, Epstein and colleagues28 showed that
bradycardia produced by vagal stimulation was
associated with a reduced incidence of serious ven-
tricular arrhythmias26 and an increased threshold for
ventricular fibrillation in the canine preparation with
myocardial ischemia. In addition, they28 found that
only PVCs closely coupled to the preceding ven-
tricular complex (<0.43 sec) were associated with
serious ventricular dysrhythmias and that atropine
effectively abolished most PVCs with longer coupling
intervals but rarely abolished closely coupled PVCs.

In our study, only one of three patients (fig. 3) with
frequent PVCs and short coupling intervals responded
to atropine therapy; the small number of patients with
PVCs associated with short coupling intervals
precludes meaningful comparison with previous data
obtained in the canine model. However, there is an
apparent difference between the effects of myocardial
ischemia in man and dog with respect to the
relationship of the PVC coupling interval and the
development of more serious ventricular arrhythmias.
De Soya et al.29 found in patients with acute myocar-
dial infarction that the mean coupling interval
between PVCs initiating serious ventricular arrhythmias
(0.59 ± 0.14 sec) did not differ
significantly from the interval in patients who did not
develop more serious ventricular arrhythmias
(0.55 ± 14 sec). In their report, 15% of the episodes of
paroxysmal ventricular tachycardia occurred at sinus
rates below 60 beats/min, but unfortunately, the
number of episodes preceded by PVCs with long
coupling intervals was not given.

Although previous studies have shown that late
coupled PVCs may be associated with ventricular arrhythmias in both dogs\textsuperscript{21} and man,\textsuperscript{20-28} the malignant potential of such PVCs in patients with acute myocardial infarction and sinus bradycardia is unknown. In view of this uncertainty, the clinician must carefully evaluate the possible risks associated with these PVCs compared with the possible adverse effects associated with any of the currently available therapeutic regimens. Furthermore, our observations that increased heart rate almost always reduced or abolished PVCs in patients with acute myocardial infarction tend to support the experimental observations of Han et al.,\textsuperscript{24} who found that the incidence of PVCs diminished with increased ventricular rate in dogs with myocardial ischemia. In addition, Chadda et al.\textsuperscript{28} found that in dogs with myocardial ischemia a heart rate between 110 to 150 beats/min was associated with a lower incidence of PVCs and/or more serious ventricular arrhythmias. Conclusions based on studies of myocardial ischemia in the open-chest dog model (with the attendant changes in autonomic tone) must, of course, be applied with caution to clinical situations.

Finally, although accelerated idioventricular rhythms appear to be transient and benign in the vast majority of patients with acute myocardial infarction, isolated reports have shown that these rhythms may, in fact, deteriorate into more serious ventricular dysrhythmias.\textsuperscript{20,26} In our study, the accelerated idioventricular rhythms associated with sinus bradycardia almost always responded to atropine therapy.

**Bradyarrhythmia-Hypotension Syndrome**

Twenty percent (17 of 83) of the patients had associated hypotension, and the incidence of this complication was especially high, 8 or 13 (61%), in patients with associated A-V block. Seven of the 17 patients with hypotension (41%) had clinical manifestations of severe impairment in systemic flow. Intravenous administration of atropine resulted in a prompt and often dramatic rise in arterial pressure in all but two patients. Our observations confirm previous reports of the beneficial effects of atropine in the prehospital phase,\textsuperscript{27} as well as in the hospital management of patients with this syndrome.\textsuperscript{9} The prompt reversal of both hypotension and impaired blood flow suggests that atropine blocks an increase in vagal tone that may be initiated from primary cardiac receptors.\textsuperscript{28-30} Although the increased heart rate produced by atropine may result in increased myocardial oxygen need and extension of myocardial ischemia (and/or further electrical instability),\textsuperscript{18,31} the rise in systemic blood pressure would be expected to counteract these effects by increasing coronary perfusion.\textsuperscript{32,33}

**Adverse Effects of Atropine Administration**

Although our studies confirm the beneficial effects of atropine in patients with acute myocardial infarction and sinus bradycardia complicated by either PVCs and/or hypotension, the effects of atropine are not totally benign (table 2). Transient sinus tachycardia and/or minor side effects characteristic of parasympatholysis developed in approximately 20% of our patients treated with atropine. Ten serious adverse effects developed in seven patients, including ventricular tachycardia or fibrillation on three occasions. Similarly, there were three instances of increased PVCs and three of sustained sinus tachycardia after atropine. The initiation of increased ventricular irritability was not necessarily preceded by sinus tachycardia. For example, in one patient (fig. 5) PVCs and ventricular fibrillation occurred after increases in heart rate that were still within the normal range. Finally, toxic psychosis, probably related to excessive atropine dosing, occurred in one patient.

**Recommended Usage of Atropine**

Review of the literature reveals widely differing recommendations regarding the dosage schedule of atropine for patients with acute myocardial infarction and bradycardia.\textsuperscript{34-38} We believe that our own observations offer useful guidelines for atropine dosing in patients with acute myocardial infarction. We found no significant difference between the increments in heart rate and blood pressure in patients receiving an initial dose of either 0.5 or 0.6 mg compared with those receiving 1.0 mg. On the other hand, the incidence of major adverse effects was lower (5%) in those receiving the lower dose than in those receiving 1.0 mg (26%). It must be appreciated that the lower dose does not completely protect the patient from serious adverse effects,\textsuperscript{8,17} but our experience suggests that such effects are much less frequent when smaller initial doses are used. In addition, all patients who received greater than 2.5 mg of atropine within the first 2½ hours had major untoward effects, accounting for 40% of the major adverse effects noted. Our data suggest intravenous administration of 0.5 or 0.6 mg of atropine initially followed by incremental doses of 0.5 mg in order to treat the specific indications listed below but not to exceed a total dose of 2.5 mg within 2½ hours.

The clinician must carefully weigh the risk/benefit ratio in the use of atropine in patients with acute myocardial infarction complicated by bradyarrhythmias. Our observations led us to the following additional conclusions. 1) Atropine administration is the drug of choice in the treatment of patients with sinus bradycardia and hypotension. It almost always results in increases in both heart rate and blood pressure, especially in patients with sinus bradycardia and atten-

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2. Atropine to self-administration is usually employed. These benefits must be weighed against the potential adverse effects of sinus tachycardia and serious ventricular arrhythmias, especially in modest sinus bradycardia associated with late coupled PVCs, because the malignant potential, if any, of this arrhythmia is presently unknown. We believe that atropine can be used safely in patients with acute myocardial infarction, provided proper attention is paid to atropine dosing, in a coronary care setting in which the adverse effects may be reversed. Unsupervised self-administration of this agent exposes the patient to a risk of potentially serious adverse effects.

3) Atropine should not be administered to patients with sinus bradycardia without ventricular irritability, hypotension, or evidence of pump failure. These patients usually have a benign clinical course.

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Circulation, Volume 52. October 1975
Use of atropine in patients with acute myocardial infarction and sinus bradycardia.
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Circulation. 1975;52:627-633
doi: 10.1161/01.CIR.52.4.627
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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