

# Myocardial Reinfarction After Anesthesia and Surgery

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• During the years 1974 and 1975 at our institution, 587 patients who had suffered previous myocardial infarctions underwent anesthesia and surgery. Thirty-six (6.1%) had a reinfarction and 25 (69%) died. Patients operated on within three months of the previous infarction had a 27% reinfarction rate. This decreased to 11% if the infarct had occurred three to six months previously and stabilized at 4% to 5% if the interval was more than six months. Risk factors associated with significantly increased reinfarction rates included preoperative hypertension, intraoperative hypotensive episodes, and noncardiac thoracic or upper abdominal operations of more than three hours' duration. Time under anesthesia was strikingly correlated with reinfarction rates in the entire group. Postoperative intensive care unit admission did not significantly affect the reinfarction rate, nor did diabetes, angina, patient age or sex, or site of the previous myocardial infarction. (*JAMA* 239:2566-2570, 1978)

MYOCARDIAL infarction is a potential complication following anesthesia and surgery. Tarhan et al,<sup>1</sup> in a study of 32,877 operations performed at the Mayo Clinic during 1967 and 1968, reported that the risk was greatly increased in patients who had suffered previous infarcts, especially if these were recent. Patients undergoing anesthesia and surgery within three months of infarction had a 37% reinfarction rate. This decreased to 16% if the previous myocardial infarction had occurred four to six months before surgery. The rate of reinfarction appeared to stabilize at approximately 5% if the previous infarct had occurred more than six months previously. This was com-

pared with a 0.13% incidence of intraoperative and postoperative myocardial infarction in patients who had no history of previous myocardial infarction who underwent an operation during the same period.

In the years following 1968, new anesthetic agents and techniques, including enflurane and neurolept-anesthesia, have been introduced, major changes in medical management have come about, and high-risk patients are more often monitored in intensive care units (ICUs). It has been suggested that reinfarction rates should have declined with these developments, and with the awareness of reinfarction as a problem.<sup>2</sup> A total of 73,321 patients underwent anesthesia and noncardiac surgery at the Mayo Clinic during 1974 and 1975. Of these, 587 had suffered previous myocardial infarctions. The records of the latter were studied in detail for predisposing factors and possible interactions between them.

## PATIENTS AND METHODS

The records of all patients with verified previous myocardial infarctions who were subjected to general or regional (spinal, epidural, caudal, and brachial plexus block) anesthesia for noncardiac operations in 1974 and 1975 were studied. A previous myocardial infarction was considered to have occurred if documented on the master sheet of the patient's record, and if that diagnosis could be supported by ECGs or appropriate enzyme studies from this or other institutions. Patient age, sex, and relevant preoperative medical problems such as diabetes, hypertension, and presence of angina were recorded. The site of and interval from the previous myocardial infarction, the site and type of surgery, all anesthetic agents, duration of anesthesia, and whether ICU care was given (the patient may have been admitted to an ICU postoperatively for reasons other than myocardial infarction) were noted. Intraoperative hypertension and hypotension were defined as a 30% increase or decrease, respectively, in systolic pressure from preoperative control occurring for at least ten minutes.<sup>3</sup> Reinfarction was verified by clinical symptoms, 12-lead ECGs, enzyme studies, or postmortem examination and was considered postoperative if occurrence was within one week of surgery and anesthesia.

The  $\chi^2$  test was used for statistical analysis except for the relationship of the reinfarction rate to the duration of anesthesia, which was analyzed by linear regression.

## RESULTS

During 1974 and 1975 at our institution, 587 patients with verified previous myocardial infarctions underwent an operation or diagnostic

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procedure under general or regional anesthesia (not including patients who had cardiac procedures). Thirty-six patients (6.1%) experienced a new myocardial infarction intraoperatively or within seven days of surgery.

**Mortality.**—Of the 36 patients who suffered reinfarction, 25 (69%) died (Table 1). Twelve patients (33%) died within 48 hours of the diagnosis of the new infarction. Of the 551 patients in whom reinfarction did not develop, only five (0.9%) died of any cause during the seven-day period following surgery. Mortality risk of those patients in whom reinfarction developed vs those in whom it did not was significantly higher ( $P < .001$ ).

**Interval From Previous Myocardial Infarction.**—Of the 15 patients who had suffered a myocardial infarction less than three months previously, postoperative reinfarctions developed in four (27%) (Table 1). Two of the 18 patients who had had previous myocardial infarctions four to six months earlier suffered postoperative reinfarctions (11%). The reinfarction rate in patients having surgery six months or more after the myocardial infarction stabilized at 4% to 5%. The difference between reinfarction rates in patients having surgery before vs after their previous myocardial infarction was six months old was significant ( $P < .01$ ).

**Age and Sex.**—There were 466 men and 121 women in the population (Table 2). There was no significant difference in the reinfarction rate between the sexes (6.0% for men and 6.6% for women). There was no significant increase with age (by  $\chi^2$  testing for patients younger than vs those older than 60 years,  $P < .1$ ). There was a high reinfarction rate among the few patients with previous infarcts who were younger than 40 years (two of eight patients). The reinfarction rate showed a trend toward an increase with age for patients older than 40 years.

**Hypertension, Diabetes, and Angina.**—Patients with preoperative hypertension requiring medical treatment had a significantly greater reinfarction rate than normotensive patients (9.4% vs 4.7%;  $P < .05$ ; Table 3). The reinfarction rates for diabetics vs nondiabetics (7.4% vs 5.9%) and preoperative angina vs no recorded angina (7.0% vs 5.9%) were not

Time of Surgery After Infarct, mo	No. of Patients	No. (%) Postoperative Reinfarctions	Deaths, No. (%)
0-3	15	4 (27)	4 (100)
4-6	18	2 (11)	1 (50)
7-12	31	2 (6)	2 (100)
13-18	30	1 (3)	0 (0)
19-24	17	1 (6)	1 (100)
>25	383	15 (4)	8 (53)
Unknown	93	11 (12)	9 (82)
<b>Total</b>	<b>587</b>	<b>36 (6.1)</b>	<b>25 (69)</b>

\*Relation to interval from previous myocardial infarction.

Age at Surgery, yr	Men		Women		% Reinfarctions, Men and Women
	No. of Patients	Reinfarctions	No. of Patients	Reinfarctions	
30-39	4	1	4	1	25
40-49	23	0	6	0	0
50-59	78	2	20	0	2
60-69	172	12	38	1	6
70-79	159	12	36	3	8
>80	30	1	17	3	9
<b>Total</b>	<b>466</b>	<b>28</b>	<b>121</b>	<b>8</b>	<b>6.1</b>

significantly different ( $P > .05$ ).

**Relation of Myocardial Reinfarction to Site of Previous Infarct.**—At the time of surgery, the site of the previous infarct was verified for 480 patients (Table 4). Sites were grouped as inferior, inferior plus anterior, anterior (including anteroseptal and anterolateral), and subendocardial infarcts. No significant differences in reinfarction rates or mortality could be found between any of these groups. The site of previous infarcts could not be definitely established from the data available at the time of surgery for 107 patients; these cases were not included in Table 4. Seven (5%) of these 107 patients suffered new infarcts and five died. On autopsy, all five had undergone subendocardial infarction before surgery. Morbidity and mortality for these 107 patients were similar to those in the other groups.

**Anesthetic Technique.**—No differences in reinfarction rates were found for the different general anesthetic techniques (Table 5). The regional anesthetics included 50 spinal, three epidural, eight caudal, and five brachial plexus blocks, with two reinfarctions occurring postoperatively in the spinal group. Transurethral prostatic resection was selected for fur-

Preoperative Status	No. of Patients	No. (%) Reinfarctions
Diabetes	121	9 (7.4)
No diabetes	466	27 (5.9)
Hypertension	181	17 (9.4)†
No hypertension	406	19 (4.7)†
Angina	200	14 (7.0)
No angina	387	22 (5.7)

\*Relation to myocardial reinfarction.  
† $P < .05$ .

ther study because of an approximately equal division between the numbers of spinal and general anesthetics; spinal anesthesia was used in 44 patients and general anesthesia in 52. Two reinfarctions occurred in the group given spinal anesthesia and one occurred in the general anesthesia group; no statistically significant difference could be demonstrated.

**Blood Pressure Changes During Anesthesia.**—Sixty-five patients had a 30% or greater rise in systolic pressure for ten minutes or more at least once during anesthesia. In these patients, the reinfarction rate was numerically higher than for patients who did not have a hypertensive episode (9.2% vs 4.4%), but the difference was not significant ( $P < .15$ ). Conversely, in the

Site of Previous Infarct	No. of Patients	No. (%) Reinfarctions	No. of Deaths
Inferior	240	13 (5)	7
Inferior and anterior	18	3 (16)	3
Anterior	189	11 (6)	10
Subendocardial	33	2 (6)	0

Thiopental Sodium, Oxygen, and Nitrous Oxide	No. of Patients	No. (%) Reinfarctions
With enflurane	234	15 (6.4)
With halothane	68	5 (7.4)
With fentanyl citrate or droperidol	146	10 (6.8)
With diethyl ether	11	1 (9.1)
Subarachnoid block (spinal)	50	2 (4.0)
Other	78	3 (3.8)

	No. of Patients	No. (%) Reinfarctions
Great vessels	69	11 (16)
Other intrathoracic	24	3 (13)
Upper abdominal	84	7 (8)
Other sites	410	15 (4)

145 patients in whom systolic pressure decreased by at least 30% one or more times for ten minutes or more during anesthesia, the reinfarction rate was significantly higher (15.2% vs 3.2%,  $P<.001$ ) than for patients who did not have such intraoperative hypotensive episodes.

**Site of Surgery.**—The reinfarction rates for operations on the great vessels, other noncardiac intrathoracic surgery, and upper abdominal operations (16%, 13%, and 8%, respectively) all were significantly greater than those for the overall group of patients ( $P<.001$  for great vessels,  $P<.05$  for other intrathoracic or upper abdominal operations; Table 6). No other operative site subgroup could be identified that had a significantly higher reinfarction occurrence than the overall rate.

**Duration of Anesthesia.**—The reinfarction rate for the entire group increased significantly with the duration of anesthesia, from 1.9% for procedures lasting less than one hour to 16.7% for procedures lasting more than six hours ( $r=0.994$ ,  $P<.001$ ; Figure).

**Interaction Between Duration of Anesthesia and Site of Surgery.**—For multifactorial analysis, the patients were

grouped according to duration of anesthesia (less than vs more than three hours) and site of surgery (intrathoracic and upper abdominal vs all other sites) (Table 7). Patients having intrathoracic or upper abdominal surgery of more than three hours' duration had a significantly higher reinfarction rate than all other groups ( $P<.05$ ). There were no significant differences between the three other groups.

**Clinical Signs and Symptoms.**—Eight patients underwent reinfarction during their operation. Clinical signs included hypotension and arrhythmias. Cardiac arrest in the operating room occurred in one patient. Only 11 of the 28 patients (39%) who suffered postoperative reinfarction experienced chest pain as verified in the record. Nine patients had cardiac arrest postoperatively without recorded prior symptoms of a developing myocardial infarction.

**Admission to an ICU Postoperatively.**—Excluding the eight patients who suffered intraoperative myocardial infarctions, 142 of the 579 remaining patients were admitted to the ICU postoperatively. Of these, reinfarctions developed in 14 (9.9%). Of the 437 patients who were not admitted to the ICU after surgery, reinfarction developed in only 14 (3.3%). Because this difference was highly significant ( $P<.001$ ), we examined it further.

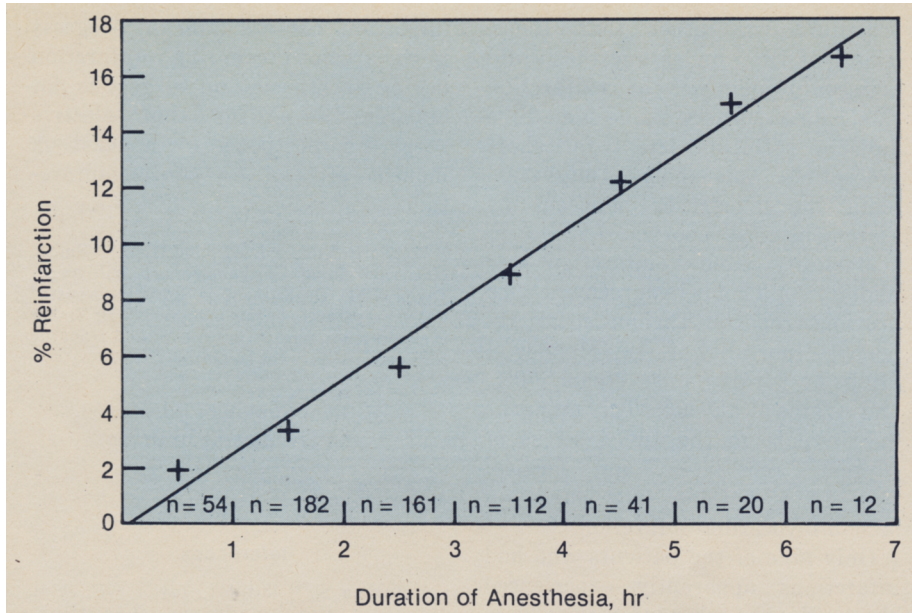
Patients who were admitted to the ICU were not a representative sample of the entire population. Patients who had great-vessel operations comprised 39% of the ICU admissions, and those who had other intratho-

racic surgery comprised an additional 15%. Both of these percentages were significantly higher ( $P<.001$ ) than the percentages of these operations in the total population. Yet, the incidence of reinfarction in patients admitted to the ICU was not significantly different from that in the overall group if an appropriate correction was made for the site of surgery. Similar correction for the fact that patients admitted to the ICU generally had longer operations gave the same result. Correction for the site of surgery was made as follows: of the 55 ICU admissions following surgery on the great vessels, 16% (nine patients) should have had reinfarctions based on the incidence in this group in the overall population (Table 5). In a like manner, the predicted incidence of reinfarction was calculated for all ICU-admitted patients. The total predicted number of infarcts in ICU-admitted patients was 15, not significantly different from the 14 actually observed. Correction for the duration of anesthesia was made in a similar manner using the expected incidence of reinfarction for different durations of anesthesia for the whole population (Figure). The total expected number of infarcts was 12, not significantly different from the 14 actually observed.

There was no correlation between ICU admittance and other predisposing factors such as short intervals from previous myocardial infarctions or preoperative hypertension. There was no difference in mortality between those admitted to an ICU postoperatively (11 of 14 admitted who had subsequent myocardial infarctions died) and those not admitted or admitted after the diagnosis of a reinfarction was made (nine of 14 who had reinfarctions died).

#### COMMENT

Although the previous study<sup>1</sup> indicated that patients have a high risk of reinfarction with anesthesia and surgery during the six-month postinfarct period, the proportion of patients with previous myocardial infarctions having surgery within zero to three and four to six months of that myocardial infarction was the same for 1974 and 1975 as for 1967 and 1968. The reinfarction rates



Relation of myocardial reinfarction to duration of anesthesia.

	Intrathoracic and Upper Abdominal, No. (%)	Other Sites, No. (%)
<3 hours		
No. of patients	68	329
Postoperative reinfarctions	4 (5.9)	12 (3.6)
>3 hours		
No. of patients	107	78
Postoperative reinfarctions	17 (15.9)	3 (3.8)

\*In relation to myocardial reinfarction.

(within one week of surgery) in these groups were high. 27% and 11%, respectively, in 1974 and 1975, and were not significantly different from those found in the previous study (37% and 16%). In agreement with previous reports,<sup>1,4,5</sup> it was apparent that the chance of a new myocardial infarction stabilized after the six-month interval.

There were four times as many men as women in the population, but there was no difference in reinfarction rates between the sexes. This is in agreement with reports on myocardial infarctions<sup>3,6</sup> and on postoperative ischemic ECG changes,<sup>7,8</sup> but not with the previous study from our institution,<sup>1</sup> which reported only a 1.4% incidence among women. The difference in reinfarction rates among the two female populations (1967 and 1968 vs 1974 and 1975) is not significant ( $P < 0.1$ ) when analyzed by  $\chi^2$  testing. Possibly, the apparent discrepancy is due to the smaller female population (73 patients) studied in 1967 and 1968.

The increase in reinfarction rates with age was not found to be significant; this is in agreement with others.<sup>1,3</sup> Reinfarction rates did appear to show an increasing trend with age, at least in patients older than 40 years of age.

The incidence of reinfarction doubled if patients had preexisting hypertension ( $P < 0.05$ ). This has not been previously noted. Patients with histories of angina or diabetes did not show significantly higher rates of reinfarction than the entire group. However, it is possible that patients with severe angina or diabetes were less likely to have surgery. Combinations of any two or all three of these preoperative factors did not change this picture. Chamberlain and Edmonds-Seal<sup>7</sup> and Rosen et al<sup>8</sup> found no correlation between postoperative ECG changes and preoperative hypertension, but these were studied in patients not selected because of previous infarcts. Chamberlain and Edmonds-Seal<sup>7</sup> studied the cases of patients with hypertension or sus-

pected ischemic heart disease, and Rosen et al<sup>8</sup> examined a general surgical population.

The sites of previous myocardial infarctions if they could be verified, could not be statistically shown to be important as determinants of risk of reinfarction. No difference in morbidity or mortality could be found between patients with previous anterior, inferior, or subendocardial infarcts. Verification of previous subendocardial ischemia is difficult at best. We cannot dismiss the possibility that a previous subendocardial infarct might lead to a different reinfarction rate. This was not the case, however, in the 33 patients in whom a preoperative subendocardial infarction could be verified.

In agreement with other investigators,<sup>1,4,5,7,9</sup> we found no significant differences in reinfarction rates between different anesthetic techniques. Forty percent of the patients in our series received enflurane and 25% received neuroleptanesthesia (fentanyl citrate, droperidol, nitrous oxide). Neither of these techniques was in use at the Mayo Clinic in 1968. Despite these newer methods, there was no significant reduction in the overall reinfarction rate from 1967 to 1968 (6.6%) and from 1974 to 1975 (6.1%).

No difference in outcome was found with spinal vs general anesthesia for the same operation (transurethral prostatic resection). Two of 44 patients had a reinfarction in the spinal group vs one of 52 in the general anesthesia group.

The numerically increased incidence of reinfarction in patients who had an intraoperative hypertensive episode was not significant, but intraoperative hypotension was associated with a significantly higher reinfarction rate, 15.2% for patients with a hypotensive episode vs 3.2% in patients without hypotensive episodes. This is consistent with other related reports,<sup>3,6,7,10-12</sup> but has not been specifically noted for patients with previous myocardial infarctions. The intraoperative hypotensive episode could be either the cause or the result of a reinfarction. Much evidence has accumulated to indicate that neither hypertension, with attendant increases in myocardial oxygen demand, nor hypotension with potential

for decreasing myocardial oxygen delivery can be well tolerated by the atherosclerotic heart. The likelihood that severe vascular obstructive lesions are associated with pressure-dependent regional myocardial blood flow, makes smoothness of the anesthetic management important.

The reinfarction rate was highest for operations on the great vessels, other intrathoracic, and upper abdominal surgery. This is in agreement with other investigators.<sup>1,8</sup>

That morbidity might increase with the duration of surgery is more controversial. Rosen et al<sup>8</sup> found that the incidence of postoperative ischemic ECG changes more than doubled when operations lasting more than one hour were compared with those lasting less than one hour. The findings of Chamberlain and Edmonds-Seal<sup>7</sup> are similar. Mauney et al<sup>3</sup> found that the average anesthesia time was significantly longer for patients who suffered a postoperative myocardial infarction than for patients with no changes in ECG (222 minutes vs 165 minutes). This has not been demonstrated by others.<sup>1,4,9</sup> In our study, the overall reinfarction rate showed a strikingly positive correlation with the duration of anesthesia ( $r=0.994$ ).

The last two variables (site of surgery and duration of anesthesia) were of special interest. The duration of anesthesia was longer for thoracic and upper abdominal surgery (mean, 3.5 hours) than for other operations (mean, 2.1 hours). The increase in repeated myocardial infarctions with increasing duration of anesthesia could be due to the length of the procedure or due to the site of the surgery. Bivariate analysis of the data (Table 7) indicated that the reinfarction rate was linked to the length of procedure if that procedure was thoracic or upper abdominal. If the

procedure was other than those, length of time under anesthesia did not seem to influence the reinfarction rate. Site of surgery at the same time did not seem important for short procedures. This analysis might explain the disparities between the aforementioned reports.

Mortality from reinfarction was high (69%). This is in agreement with previous reports. Tarhan et al<sup>1</sup> reported a mortality of 54%; Mauney et al,<sup>3</sup> 53%; Topkins and Artusio,<sup>4</sup> 70%, and Arkins et al,<sup>5</sup> 80%. This might be due in part to the added stress of surgery, anesthetics, and surgical pain in a patient experiencing a second myocardial infarction.

Only nine of the patients who had infarctions apparently experienced chest pain; the other infarctions were discovered through ECG monitoring, at the time of a cardiac arrest, or at autopsy. This lack of subjective symptoms has been pointed out by others<sup>9,10,13</sup> and may reflect residual anesthetics and analgetics administered postoperatively.

Twenty-five percent of the patients were admitted to the ICU after surgery. Whether or not a patient was admitted did not in itself influence the incidence of reinfarction or mortality in any group.

We conclude that, in our institution, incidence and severity of reinfarction following anesthesia and surgery in patients with previous myocardial infarction is statistically unchanged from the earlier (1967 to 1968) period, despite apparent major changes in perioperative management. We further conclude that the increased risk of reinfarction is associated with thoracic and upper abdominal procedures and with length of the procedure in these patients, that preoperative hypertension is a contributing factor, and that episodes of hypotension during anesthesia are

important. Since significant progress in the area of preventing reinfarction during anesthesia and surgery is not apparent, we urge that elective surgery be postponed for at least six months after a myocardial infarction.

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#### Nonproprietary Names and Trademarks of Drugs

Droperidol—*Inapsine*.  
Enflurane—*Ethrane*.

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