Supraventricular Tachycardia Complicating Surgical Procedures

A Study of the Contributing Causes, Course, and Treatment of this Complication in Fifty Patients

By WAYNE R. ROGERS, M.D., FELIX WROBLEWSKI, M.D., AND JOHN S. LA DUE, M.D., PH.D.

THE OCCURRENCE of supraventricular tachycardia during and following surgical procedures is a relatively infrequent but dangerous complication. Several case reports emphasizing its importance following chest surgery have been published,1–3 but little is known of the incidence and behavior of such arrhythmias in other types of surgery.4–8, 11 We have studied these arrhythmias as they developed during the operative and postoperative course of 50 patients (54 instances of arrhythmia) with particular reference to: (1) underlying and precipitating causes; (2) course of the arrhythmia, including its response to treatment; and (3) the influence of the complication upon the surgical outcome and subsequent cardiac status.

MATERIAL

The electrocardiograms taken at Memorial Center between Jan. 1, 1946 and Sept. 1, 1951, interpreted as showing the postoperative onset of supraventricular tachycardia, were reviewed; 54 instances of this electrocardiographic abnormality formed the basis of this study and included 15 patients with auricular fibrillation, six patients with auricular flutter, four with flutter-fibrillation, two with auricular tachycardia, six with nodal tachycardia and 12 in whom the rhythm was clearly supraventricular but the exact focus of origin unidentified, henceforth classified as a group as supraventricular tachycardia. Nine patients had multiple arrhythmias. Patients with sinus tachycardia or tachycardia due to auricular or ventricular premature contraction were excluded. Ventricular tachycardia was not encountered. The charts of these patients were reviewed, and the data classified according to the headings which precede each discussion.

Observations

Incidence

Fifty patients developed supraventricular tachycardia during or within 18 days of operation. Four had second operations followed by recurrent arrhythmia, making a total of 54 instances of this complication. No instance of arrhythmia unconfirmed by electrocardiogram is included, although a number of these occurred during the period covered by this study. Hence, we cannot give the exact incidence of supraventricular tachycardia following operations done at Memorial Center, but it would appear to be well under 1 per cent, since approximately 28,000 operations were performed during this five and two-thirds year period. Thirty-one of the patients were males; 19 were female. Forty-eight were white, two were colored. The age range was from 15 to 78 years, with a mean of 62.1 years and a median of 63 years. Ninety per cent were 50 years or older, 70 per cent 60 years or more of age.

Concomitant Diseases

Of the 50 patients, 14 had generalized arteriosclerosis; seven were obese; two had diabetes mellitus; two, benign prostatic hypertrophy; two, latent syphilis; three, thyroid

From the Medical Service of Memorial Center for Cancer and Allied Diseases, New York City, N. Y.
adenomas of which two had once been toxic; three had emphyema; one, parkinsonism; and one was an alcoholic. Twenty patients exhibited no significant disease other than the surgical condition necessitating their hospital admission.

Preoperative Cardiac Status

Twenty-one patients (42 per cent) had no history or laboratory evidence of heart disease preoperatively. The most prevalent cardiovascular disease was essential hypertension, which was found in 19 patients (38 per cent). Arteriosclerotic heart disease was present in 10 patients (20 per cent); this was evidenced in seven (14 per cent) by a history of angina pectoris and in three (6 per cent) by a history of healed myocardial infarction. One patient had rheumatic heart disease (mitral stenosis); another had mild thyrotoxic heart disease and a third had noncyanotic congenital heart disease. Five patients (10 per cent) had had cardiac arrhythmias prior to their first operative procedure, although in two of these there was no other evidence of cardiac disease. All patients had normal sinus rhythm at the beginning of surgery, and none showed evidence of congestive failure.

Cardiac enlargement was found in nine patients (18 per cent), confirmed in seven by chest x-ray films. In 40 (80 per cent) of the remaining 41 patients the cardiac size was recorded as normal; in 38 of these this clinical impression was confirmed by x-ray films of the chest.

An estimate of each patient’s preoperative functional capacity was made, and the results were classified according to the method of the New York Heart Association. Of the 50 patients, 27 (54 per cent) were in class I, 19 (38 per cent) in class II and the remaining four (8 per cent) in class III.

Preoperative Electrocardiographic Findings

Preoperative electrocardiograms were obtained from 42 of the patients. Thirteen (31 per cent) of these tracings showed myocardial disease with normal sinus rhythm; of the 13, three had ventricular premature contractions, and one had both ventricular and auricular premature contractions. Of the 29 tracings (69 per cent) showing no evidence of myocardial disease, three had ventricular premature contractions, one had auricular premature contractions, and one had both ventricular and auricular premature contractions. Thus, of the 42 preoperative electrocardiograms, six (14 per cent) showed ventricular premature contractions only, one (2 per cent) showed auricular premature contractions only, and two (4.7 per cent) showed both ventricular and auricular premature contractions, making the total incidence of premature contractions 21 per cent. In comparison, out of 100 random electrocardiograms taken preoperatively in our laboratory, eight showed ventricular premature contractions, and one showed auricular premature contractions, an incidence of 9 per cent.

Cardiac Medication

Medication for heart disease, per se, was given to nine patients prior to their first operation. Of this number, five received digitalis, one quinidine, two both quinidine and digitalis and one received procaine. Of the four patients suffering second attacks of postoperative cardiac arrhythmias, one received digitalis and one was given both digitalis and quinidine prior to the second operation. Forty-one patients received no specific cardiac therapy preoperatively.

Operative Data

Of the 54 operations, 45 were major, averaging 3.6 hours in duration. The remaining nine were minor in the sense that the surgical procedure lasted less than one hour. Fifty-three of the 54 surgical procedures were done under anesthesia. Three patients (5.6 per cent) received ether, 21 (40 per cent) ether with induction by nitrous oxide, five (9 per cent) Pentothal alone, seven (13 per cent) Pentothal and local combined, six (11 per cent) Pentothal plus inhalation anesthesia, seven (13 per cent) spinal and four (7.5 per cent) local anesthesia.

The regional distribution of these operations was as follows: head and neck, nine (17 per cent); chest, 20 (37 per cent); abdomen, 14 (26 per cent); pelvis, five (9 per cent); extrem-
are included: congestive heart failure, three, hypotension in three, pericarditis in two, cardiac arrest in one, pulmonary edema in one, and digitalis toxicity in two. Less definite but possible causes were mediastinal shift in eight patients, pulmonary infarcts in three, extensive atelectasis in three, bronchopneumonia in two, mediastinitis in two, bronchial stump leak in one and spontaneous pneumothorax in one. Incidental and less clearly associated complications included: abdominal distention, five; terminal cachexia, four; lower nephron nephrosis, two; peritonitis, two; septicemia, one; and transfusion reaction, one.

Miscellaneous Factors

The average oral temperature of the 43 patients who were febrile at the onset of arrhythmia was 102 F., with a range of 99 to 104 F. Seven patients were afebrile. The hemoglobin level within 24 hours of the occurrence of arrhythmia was below 12 Gm. per 100 cc. in 11 patients, 12 to 17 Gm. per 100 cc. in 34 patients and above 17 Gm. per 100 cc. in three; this datum was not available in two patients. In four patients no predisposing cardiac disease nor any operative or postoperative complication could be found to account for the occurrence of the tachycardia.

Course of Arrhythmias

Onset and Duration

In table 1 the arrhythmias are tabulated according to time of onset and total duration. In 11 patients (20 per cent) the onset was intraoperative and in 43 (80 per cent) the abnormal rhythm developed within 6 hours to 18 days postoperatively. The median time was three days, the average 4.9 days. It is noteworthy that in 45 per cent the onset of the arrhythmia was observed to occur after the second postoperative day. Abnormal rhythm persisted for over five days in 16 instances (30 per cent), for one to five days in 14 (27 per cent), and terminated within 24 hours in the remaining 24 (43 per cent). It is our custom to try carotid sinus pressure and compression of the eyeballs prior to giving any drug therapy to patients with supraventricular tachycardia.

Fifty-three of the 54 instances of arrhythmia
were treated with specific cardiac drugs. In 42 (78 per cent) reversion to normal sinus rhythm was observed; however, the arrhythmia occurred in 14 of these. In 12 patients (22 per cent) the arrhythmia was refractory to therapy, and in six of these patients it was a major cause of death.

Treatment

Digitalis. Adequate doses of a cardiac glycoside were used in the treatment of 42 of the arrhythmias. In 25 patients it was the only specific drug given; control of the arrhythmia with reversion to normal sinus rhythm was observed in 18 instances. Sixteen patients were given both digitalis and quinidine with reversion of the arrhythmia in 13; in four of these patients digitalis alone, rather than the small doses of quinidine employed, appeared to be responsible for the reversion. One of these patients receiving other specific drugs (procaine, acetylcholine and Pronestyl) did not revert to normal sinus rhythm until digitalis was given. Thus, of the 42 patients given cardiac glycosides, 22 were apparently controlled primarily by the glycoside. Of the remaining 20, 10 were controlled as a result of the administration of quinidine or other specific treatment than digitalis. In the other 10 patients, the arrhythmia was never brought under prolonged control, although five reverted to normal sinus rhythm transiently. Three of these received other specific medications in addition to digitalis.

Digitalis was given intravenously to 22 patients, 20 receiving lanatoside C and two digitoxin. Of the 11 given the full digitalizing dose at once, three established normal sinus rhythm in less than 12 hours; three within 12 to 48 hours; two took 48 hours or more and in three the arrhythmia persisted. When the glycoside was given intravenously in divided doses over a 12-hour period to 11 patients, normal sinus rhythm was established in less than 12 hours after completion of digitalization in three instances, within 12 to 48 hours in five, in more than 48 hours in one, and in two the arrhythmia remained uncontrolled.

Digitalization was effected by intramuscular administration in nine patients, five of whom were given digitoxin, three Digalen and one lanatoside C. Of the three given the full digitalizing dose in the first injection, one reverted to normal sinus rhythm within 12 to 48 hours, one in 48 hours, and in one the arrhythmia persisted. One patient given intramuscular digitoxin in three 0.4 mg. injections over a 10-hour period reverted to normal sinus rhythm after the last dose. In five patients digitalization was spread over a 12 to 24 hour period; in two of these normal sinus rhythm was established 12 to 48 hours later; in two the arrhythmia disappeared more than 48 hours later, and one remained arrhythmic.

Table 1.—Time of Onset and Duration of 54 Instances of Cardiac Arrhythmias

<table>
<thead>
<tr>
<th>Time of Onset</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Number of Cases)</td>
<td>(Number of Cases)</td>
</tr>
</tbody>
</table>

| Intraoperatively | 11 |
| Postoperatively |  |
| 1 Hour | 1 |
| 6 Hours | 6 |
| 12 Hours | 5 |
| 1 Day | 15 |
| 2 Days | 13 |
| 3 Days | 5 |
| 4 Days | 3 |
| 5 Days | 4 |
| >5 Days | 12 |
| Uncontrolled | 12 |
| Totals | 54 |

The glycoside was given by mouth in 11 instances, 10 receiving 1.2 mg. or more of digitoxin and one 1.5 Gm. of digitalis leaf. Of the three given the full dose immediately, one established normal sinus rhythm within 12 hours, another in two days, and in the third the abnormal rhythm persisted. Four were digitalized over a 1 to 12-hour period with reversion to normal sinus rhythm within 12 hours after digitalization in one patient, in 12 to 48 hours in one, in 10 days in another; in the fourth the arrhythmia persisted. Four were digitalized slowly over a 12 to 36-hour period, one reverting 24 hours after full digitalization, two in two and five days respectively, and one remaining arrhythmic.

Thirteen patients developed congestive heart
failure: three before and 10 after the onset of arrhythmia. Ten were given a cardiac glycoside, all in adequate dosage. In four of these the heart failure cleared. In two the heart failure had cleared before the establishment of normal sinus rhythm; in one the heart failure disappeared rapidly after cessation of the arrhythmia. One patient manifested signs of congestive heart failure for six days after reversion to normal sinus rhythm. Two patients had persistent evidence of congestive heart failure despite adequate digitalization and control of their arrhythmia. Four patients were apparently unaffected by the administration of digitalis, both the arrhythmia and the congestive heart failure persisting until death. Three patients with congestive heart failure were not given digitalis; all died 3 to 12 weeks postoperatively with the persistent arrhythmia and heart failure being the major cause of death.

Four of the 42 patients receiving a digitalis preparation were intoxicated by the drug; two of these developed an arrhythmia concomitant with the intoxication. One patient who had been completely digitalized one week previously was mistakenly given 6 cat units of folia digitalis within four days and developed supraventricular tachycardia during the ensuing period of nausea and vomiting. Through error, another patient was given 10 mg. of digitoxin instead of 1 mg. and six hours later developed auricular fibrillation. Both of these arrhythmias reverted promptly when digitalis was stopped and quinidine given.

Quinidine. Following the onset of arrhythmia in 22 patients a quinidine preparation, most frequently quinidine sulfate, was administered. The intramuscular route was used in one patient to whom a total of 0.6 Gm. was given with reversion of the arrhythmia within 12 hours after the institution of therapy. Quinidine was given by mouth to 21 patients, 11 of whom simultaneously received other cardiac drugs. Normal sinus rhythm appeared in 15, and quinidine was felt to be primarily responsible for the reversion. Dosage varied from 0.4 to 18.0 Gm. given over a period of from eight hours to 11 days. The average dose was 3.9 Gm. given over an average time of 50 hours. In most patients the dose of quinidine was less than optimal, and no instance of cinchonism was encountered.

Eight patients with arrhythmia were treated with quinidine alone; two reverted to normal sinus rhythm within 12 to 24 hours, three within 24 to 48 hours, and in three instances the arrhythmia persisted. Seven patients who had been treated with digitalis glycosides without reversion developed normal sinus rhythm when quinidine was given, four in 12 to 24 hours, two within 24 to 48 hours, one requiring four days. There were five instances in which the administration both of quinidine and of digitalis failed to control the abnormal rhythm. Maintenance doses of quinidine ranging from 0.2 Gm. to 1.6 Gm. per 24 hours were given to 13 patients, but the arrhythmia recurred in four instances; the maintenance dosages of quinidine in these four patients were 0.9 Gm., 1.2 Gm., 1.2 Gm. and 1.6 Gm. per 24 hours. Four of nine patients not getting maintenance doses of quinidine had recurrence of arrhythmia.

Other Therapy

Vagal stimulation by means of ocular or carotid sinus pressure was recorded as having been tried in six patients, with a transient response in one; subsequently cardiac drug therapy accomplished reversion of the arrhythmia in all six.

Two patients received procaine intravenously (0.5 Gm.). In one, auricular tachycardia reverted to sinus rhythm within four hours; in the other auricular flutter persisted. Two patients received procaine amide. One with auricular tachycardia was unaffected by 0.5 Gm. intravenously; one with multiple arrhythmias reverted within three days, during which he received a total of 3.5 Gm. orally. Two patients received Prostigmin subcutaneously, and one with nodal tachycardia reverted within two hours after the administration of 1.0 mg. but the arrhythmia recurred three days later and did not respond subsequently to 0.5 mg. The other, a patient with auricular tachycardia, received 0.5 mg. twice without definite response. Three patients were given acetylcholine intravenously, and one with supraventricular
tachycardia reverted immediately after having received 20 mg.; one instance of auricular tachycardia and one of auricular flutter did not respond respectively to 10, 20, 30 or 40 mg. doses given separately over a 12 hour period.

Uncontrolled Arrhythmias

Of the 12 uncontrolled arrhythmias four were multiple types, three were auricular fibrillation, three were nodal tachycardia and two were unidentified supraventricular tachycardias. Some of the factors apparently contributing to persistent arrhythmia include organic heart disease noted preoperatively (10 patients), postoperative extracardiac complications with stormy course (six patients), preceding postoperative myocardial infarction and heart failure (four patients), and probably inadequate cardiac drug therapy (eight patients). Eight of these 12 patients developed heart failure; in two its onset preceded the arrhythmia. Four died primarily of heart failure; five died of infection, one of malignancy and one of cardiac arrest. Of the three patients with auricular fibrillation, two were receiving 0.2 mg. of digitoxin daily; the ventricular rate of one was consistently above 100 per minute while that of the other was below 100 per minute. In seven of the nine patients with other types of arrhythmias the heart rates were faster than 100 per minute terminally. In the remaining two patients these data were not recorded.

End Results

Twenty of the 50 patients were living at the time of last follow-up; the duration of this period postoperatively ranged up to 38 months, with an average of 12 months. None of these patients showed evidence of cardiac arrhythmia or of heart failure. Eight were maintained on digitoxin, and none was taking quinidine.

Thirty of the 50 patients have died, all within two years postoperatively, with an average postoperative survival of five and two-tenths months. At the time of death, nine had no evidence of cardiac failure or arrhythmia; four had the arrhythmia only; two had heart failure with normal rhythm; 11 had heart failure and arrhythmia. The cardiac status of four patients at the time of death was unknown. Ten patients were taking digitoxin. Nine of the 30 deaths were due to cardiac disease; persistent cardiac arrhythmia with ensuing heart failure was the major factor in the death of six of these; of the remaining three, two died of myocardial infarction and one of cardiac arrest. Six deaths were due to malignancies, six to infection, four to pulmonary infarctions and the other five to various extracardiac diseases.

Discussion

Although it is difficult to anticipate which patients will develop cardiac arrhythmias as a complication of surgery, 79 per cent of our patients had preoperative evidence of heart disease and/or clinically evident auricular or ventricular premature contractions. Preventive measures should include preoperative control of the extrasystoles supplemented by the use of digitalis when indicated.

Intraoperative systolic hypotension to 100 mm. Hg or less and postoperative cardiopulmonary complications appeared to be causally related to the onset of the arrhythmias. Anemia, fever, and parenteral administration of fluids or blood did not seem to be contributory. Combinations of these and other factors listed elsewhere appeared to be operative as suggested by the fact that 45 per cent of the arrhythmias developed after the second postoperative day.

Twenty per cent of the abnormal rhythms had their onset during the operation; trauma to the heart or to related autonomically innervated structures, cardiac arrest and pulmonary edema were possible precipitating causes in 5 of the 11 instances. The type of anesthesia given did not appear to be of import etiologically, but a significant fall in systolic blood pressure to less than 100 mm. Hg was noted in 63 per cent. The possible importance of hypoxia or anoxia could not be evaluated.

In the present study the cardiac arrhythmias responded slowly to therapy probably because of the serious organic disease responsible for their etiology. Vagal stimulation was almost wholly ineffective, while cardiac therapy was
only moderately successful. Of the 22 instances of arrhythmias thought to have been reverted by digitalis action, only eight occurred within 12 hours following the administration of the full digitalizing dose. Of the nine instances of arrhythmias thought to have been reverted by quinidine action, only three reverted within 12 hours following institution of therapy, but perhaps this can be explained in part by the cautious dosage schedules.

Prompt attention to possible precipitating causes such as infection, heart failure, fluid and electrolyte imbalance, and pulmonary and renal complications is demanded in addition to specific therapy. We recommend prompt digitalization, intravenously by preference; give 1.6 mg. of lanatoside C within a period of five minutes to patients who are not receiving maintenance doses of digitalis; follow the initial digitalizing dose by 0.2 mg. of digoxin daily and change the daily amount according to accepted standards. If the arrhythmia persists for 48 hours quinidine is given in dosages of 0.4 to 0.6 Gm. every three hours until the arrhythmia reverts or toxicity develops. Although procaine and procaine amide are considered to be relatively ineffective in supraventricular tachycardia, it is desirable to employ them when digitalis and/or quinidine have proven ineffective. Should the irregularity persist after 48 hours of quinidine and digitalis therapy, an infusion of 1,000 cc. of procaine, 0.1 per cent in 5 per cent glucose, is started and continued at a rate of 50 to 70 drops per minute until normal sinus rhythm is established. Instead of procaine, procaine amide may be given intravenously at the rate of 200 mg. per minute up to 1 Gm. total, or until arrhythmia ceases. With such measures, 80 to 90 per cent of these arrhythmias may revert to normal sinus rhythm. Both digitalis and quinidine should then be continued until the patient is fully ambulatory or longer if there are other indications for continued therapy. The patient who is taking maintenance digitalis when paroxysmal tachycardia develops is treated at once with quinidine and/or other medications as described above.

In the series reported here, supraventricular tachycardia resulted in little or no damage to the 38 patients who responded favorably to therapy, but the 12 patients in whom the abnormal rhythm could not be controlled survived an average time of only 3.6 months. Six died of heart failure, all within five months, and in seven others the cardiac complication contributed to death. The heart failure associated with uncontrollable arrhythmia was also usually refractive to treatment, and of eight such patients six died of congestive heart failure. Had the treatment of the arrhythmia and of the heart failure been more intensive, as above recommended, a few of the eight patients who were inadequately treated might reasonably have been expected to respond more favorably.

**SUMMARY AND CONCLUSIONS**

1. Fifty-four instances of cardiac arrhythmia developed as an operative or postoperative complication among 28,000 operations done at Memorial Center from 1946 to 1951.

2. All of the arrhythmias were supraventricular in origin and consisted of 15 instances of auricular fibrillation, 12 of unidentified supraventricular disturbance, nine of multiple arrhythmias, six of auricular flutter, six of nodal tachycardia, four of flutter-fibrillation, and two were auricular tachycardia.

3. Operations in the thorax were most frequently complicated by arrhythmias (20 instances), with operations in the abdomen (14 instances), and head and neck (13 instances) next in frequency.

4. In 42 per cent of patients cardiac disease was not detected preoperatively.

5. Hypertensive cardiovascular disease was present preoperatively in 38 per cent of the series, arteriosclerotic heart disease in 20 per cent, with cardiac enlargement being noted in only 18 per cent. By New York Heart Association criteria 54 per cent were class I, 38 per cent class II and 8 per cent class III.

6. Abnormal electrocardiograms were found preoperatively in 31 per cent, premature contractions in an additional 10 per cent.

7. The presence of auricular or ventricular premature contractions preoperatively justifies the preoperative control of these irregularities with quinidine or procaine amide.

8. The arrhythmia developed at operation in 20 per cent, postoperatively in 80 per cent,
with a median time of onset of three days. Forty-five per cent developed two or more days postoperatively.

9. A blood pressure fall to 100 mm. Hg or less, operative manipulation, temporary cardiac arrest and pulmonary edema were probably causes of the cardiac irregularities noted during surgery.

10. Postoperative pulmonary infarcts, infection, hypotension, pneumothorax, digitalis toxicity, fever, abdominal distention, cachexia and lower nephron nephrosis appeared to play a part in precipitating the arrhythmia postoperatively. Four patients had no discernible precipitating cause.

11. Cardiac glycosides were apparently effective in establishing normal sinus rhythm in 40 per cent of the arrhythmias, quinidine in 15 per cent, and miscellaneous measures in 22 per cent; 23 per cent of the arrhythmias were uncontrolled by any measure.

12. The average duration of the cardiac irregularity before normal sinus rhythm was established was 30 hours; these patients showed no apparent permanent damage from the arrhythmia.

13. Of the 12 patients in whom the arrhythmia was uncontrolled, 10 showed evidence of heart disease preoperatively. Eight of these patients developed congestive heart failure, five dying as a result. Persistent arrhythmia despite adequate treatment is a bad prognostic sign and cardiac failure due to or associated with arrhythmia responds poorly to treatment.

14. The prompt administration of digitalis and/or quinidine to patients developing supraventricular tachycardia preoperatively is recommended. Persistent failure to revert to normal sinus rhythm justifies a trial of procaine, procaine amide, and possibly acetylcholine or Mechoyl.

15. Twenty patients are living and well without any evidence of heart disease 4 to 38 months (averaging 12 months) after the onset of their arrhythmia.

16. Thirty patients are dead, nine dying of heart disease, six of recurrent cancer, six of infections, four of pulmonary infarcts and five of other diseases.

SUMARIO ESPAÑOL

Taquicardia supraventricular postoperatoria persistente no obstante tratamiento adecuado es un signo de pronóstico malo y decompensación cardíaca debida o asociada con la arritmia responde pobremente a tratamiento. De los 12 pacientes (24 por ciento) no respondieron a tratamiento, ocho desarrollaron decompensación cardíaca, cinco muriendo como resultado. Los factores preoperatorios, intraoperatorios y postoperatorios que contribuyen como causa a esta complicación se revisan, y la terapia, curso y resultados se discuten.

REFERENCES


Supraventricular Tachycardia Complicating Surgical Procedures: A Study of the Contributing Causes, Course, and Treatment of this Complication in Fifty Patients
WAYNE R. ROGERS, FELIX WROBLEWSKI and JOHN S. LADUE

Circulation. 1953;7:192-199
doi: 10.1161/01.CIR.7.2.192

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1953 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/7/2/192

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/