Acute Alterations of the Electrocardiogram Following Thoracic Surgery

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While occurrence of disturbances of cardiac rhythm during and after general surgical procedures has been known for many years interest in the subject was revived only recently with the advent of thoracic and in particular cardiac surgery. A number of reports dealing with postoperative changes of the electrocardiogram have appeared, mostly after pulmonary resection. Various arrhythmias have been noted postoperatively often associated with transient surgical pericarditis and diverse factors have been implicated in their development.

In the course of our own observations we have been impressed by the high incidence of arrhythmias developing in patients undergoing surgery for carcinoma of the esophagus, a point previously not stressed. Furthermore, a characteristic electrocardiographic pattern was found consistently in our patients who developed surgical pericarditis after mitral commissurotomy. These two features as well as the incidence and analysis of the causes of disturbances of rhythm in our entire patient material submitted to thoracic and cardiac surgery are the subject of the present report. Changes in electrocardiographic contour attributable to the surgical trauma of the heart itself and to hemodynamic alterations following surgical procedures for the correction of congenital heart disease are at present under study.

Material and Methods

Clinical records and the electrocardiograms of 135 patients who underwent various types of thoracic or cardiac surgery at Michael Reese Hospital have been reviewed. Of these, 66 had at least one postoperative electrocardiogram. In 55 (Table I) the presence of sinus rhythm before surgery had been established on clinical and/or electrocardiographic grounds. There were 34 females and 32 males in this group. The ages ranged from six months to 78 years (Table III). Our material was classified as to the time of appearance of arrhythmias (Table IV), development of pericarditis (Table II) or a combination of both. The incidence of these alterations was related to the type of surgery performed (Tables I and II) and to the ultimate prognosis of these patients (Table III). Excluded from this study were those with simple postoperative sinus tachycardia or with occasional premature systoles appearing after surgery. No case of ventricular paroxysmal tachycardia was encountered.

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Results

Disturbances of rhythm developed in 20 instances (Table I). Electrocardiographic evidence of pericarditis was found in 27 and questionable changes in three (Table II). Both arrhythmia and pericarditis occurred in 10 who had sinus rhythm prior to operation. There was a definitely higher incidence of arrhythmias in the older age group (Table III). Auricular flutter or fibrillation were the most common arrhythmias encountered (75 per cent) regardless of type of surgery and was the only disturbance of rhythm occurring following mitral commissurotomy. It developed in seven of the 13 patients in this latter group who had sinus rhythm prior to surgery. Paroxysmal auricular fibrillation and auricular premature systoles also developed in two in whom the pericardium was opened in the course of left pneumonectomy. In each of these instances arrhythmia was detected simultaneously with or after the onset of surgical pericarditis. On the other hand none of the four submitted to pulmonary valvulotomy developed an arrhythmia. Among the 10 patients who underwent surgery for carcinoma of the esophagus (esophagectomy with or without gastrectomy and one instance of exploratory thoracotomy), disturbances of rhythm were noted in seven—all of whom died within one to 22 days (Table III).

Most of the disturbances of rhythm occurred within five days after

FIGURE 1: A typical postoperative electrocardiogram in a 42 year old fully digitalized patient, four days after mitral commissurotomy (only the two chest leads shown could be recorded because of bandages on chest.) Auricular fibrillation is present. Note the elevated S-T junction in leads II, III, aVF and V5, the downward sloping S-T segment and the short Q-T interval, a combination considered characteristic for a pericarditis pattern modified by digitalis effect (cf. Figure 2).
operation (Table IV). In three instances the onset was delayed more than 10 days and in one auricular fibrillation appeared 24 days after mitral commissurotomy. In this last patient first and second degree A-V block developed at first during the immediate postoperative period, the only instance of disturbance of A-V conduction observed in our series. Reactivation of the rheumatic process was considered to have occurred in this patient. In the other three, a late arrhythmia developed in the course of grave postoperative complications, viz., tuberculous bronchopneumonia, pulmonary infarction and sero-fibrinous or fibrino-purulent pericarditis,

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total Number</th>
<th>Auricular Fibrillation</th>
<th>Auricular Premature Syctole</th>
<th>Supraventricular Tachycardia</th>
<th>Nodal Premature Syctole</th>
<th>Nodal Paroxysmal Tachycardia</th>
<th>A-V Block</th>
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<tr>
<td>Mitral commissurotomy</td>
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<td>7</td>
<td></td>
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<tr>
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<td>4</td>
<td>1</td>
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<tr>
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<tr>
<td>*Thoracotomy (left) (for repair of spontaneous perforation of esophagus)</td>
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<tr>
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<tr>
<td>Pneumonectomy (left)</td>
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<td>2</td>
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<tr>
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<tr>
<td>Dusting of pericardium</td>
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<tr>
<td>Decortication (right lung)</td>
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<tr>
<td>Patent ductus arteriosus</td>
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<tr>
<td>Pulmonary valvotomy</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>55</td>
<td>15</td>
<td>1</td>
<td>2</td>
<td>1</td>
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<td>1</td>
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</tbody>
</table>

*Same patient.
the latter as the consequence of a fistula between a esophago-gastrostomy and the pericardial sac.

The pericardium was opened in the course of the operation, on purpose or inadvertently in 33 patients (Table II). Twenty-six (78.7 per cent) developed definite electrocardiographic evidence of pericarditis. In addition there was one instance with electrocardiographic changes suggestive of pericarditis after right pneumonectomy though pericardiotomy was not performed. Necropsy findings in five who underwent mitral commissurotomy and died in the immediate postoperative period (one of them not included in the present study because of the absence of postoperative electrocardiograms) have shown the presence of fibrinous pericarditis in every instance. In two, no electrocardiographic alterations of pericarditis were found even though a pericardial friction rub was detected clinically in both.

The electrocardiographic alterations caused by surgical pericarditis consisted in the usual S-T deviations found in other types of acute pericarditis with the usual evolution over three to four weeks. In several instances however the electrocardiogram returned quickly, within one or two weeks, to the preoperative pattern without going through intermediate stages of T flattening and inversion. Tracings recorded in early pericarditis after mitral commissurotomy revealed a strikingly similar and characteristic appearance (Figures 1 and 2) attributable to the modification of the ordinary pericarditis pattern by the concomitant digitalis therapy.

Discussion

Postoperative arrhythmias. The causes of disturbances of cardiac rhythm following surgical procedures have been studied experimentally and analyzed clinically. It would appear that age plays a role in their development since arrhythmias seldom occur when thoracic surgery is performed in patients under 40 years of age, in particular auricular fibrillation. However, coronary disease seems to bear no direct relationship to its incidence. In our 20 patients who developed a postoperative arrhythmia, evidence of coronary involvement was present only in two.

Experimental data suggest that hypoxemia may be responsible for

![Figure 2](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21287/)

**FIGURE 2**: Lead II in *six different digitalized patients* two to six days after mitral commissurotomy showing the three kinds of electrocardiographic findings. Auricular fibrillation was present in all except the first. In all the S-T junction is elevated, S-T forms a downward slope and merges with a diphasic or upright T wave while Q-T appears fore-shortened. In the first four cases S-T starts from an S wave, and in the middle two the latter is pulled above its reference level; in the last two cases the elevated S-T merges with a terminal notching of QRS, an equivalent of an S wave. These three types of electrocardiographic alterations are attributable to the combined effects of an acute pericarditis and of digitalis.
development of some types of cardiac arrhythmias,\textsuperscript{10, 19, 20} and this has to be considered especially in cases of total pneumonectomy. Bailey and Betts\textsuperscript{1} noted a relationship between the varying extent of pneumonectomy and the incidence of disturbances of cardiac rhythm. Among our four patients who underwent resection of a single lobe auricular fibrillation occurred in only one, a 51 year old female with tuberculosis. Prior to its onset postoperative complications developed including pneumothorax with collapse of the remaining lobes of the operated lung.

It is well known that vagal stimulation facilitates the experimental production of auricular flutter and fibrillation.\textsuperscript{12, 16, 18, 20} Vagal stimulation during infection of the bronchial stump has been implicated as a cause of occurrence of this arrhythmia after pneumonectomy.\textsuperscript{1} But vagal irritation can be expected to occur in any type of intrathoracic surgical procedure and need not necessarily be related to this particular event. That this is so is

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|}
\hline
Operation & Total Number of Cases & Number with Pericardium Opened & Number with Definite ECG Evidence & Number with Questionable ECG Evidence \\
\hline
Mitral commissurotomy & 24 & 24 & 18 & 2 \\
Pulmonary valvotomy & 4 & 4 & 3 & 1 \\
Dusting of pericardium & 3 & 3 & 3 & 0 \\
Pneumonectomy & 3 & 2 & 3 & 0 \\
\hline
TOTAL & 34 & 33 & 27 & 3 \\
\hline
\end{tabular}
\caption{Electrocardiographic evidence of pericarditis in relation to the type of surgical procedure.}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|c|}
\hline
Age in Years & Total Number of Cases & Arrhythmia & Per Cent & Deaths \\
\hline
0 - 10 & 7 & 0 & 0 & 0 \\
10 - 20 & 4 & 1 & 25 & 0 \\
20 - 30 & 6 & 2 & 33.3 & 0 \\
30 - 40 & 9 & 4 & 44.5 & 1 \\
40 - 50 & 12 (1)** & 3 (1)** & 25 (1)** & \\
50 - 60 & 7 (3) & 3 (2) & 43 (2) & \\
60 - 70 & 6 (2) & 4 (1) & 66.3 (1) & \\
70 - 80 & 4 (4) & 3 (3) & 75 (3) & \\
\hline
TOTAL & 55 (10) & 20 (7) & 36 & 8 (7) \\
\hline
\end{tabular}
\caption{Postoperative arrhythmias in relation to age and outcome*}
\end{table}

*All cases had preoperative Sinus Rhythm.

**Numbers in parenthesis indicate patients with carcinoma of esophagus.
suggested by the high incidence of auricular arrhythmias in our patients operated for carcinoma of the esophagus (Table I). Postoperative arrhythmias in this group may bear a relation to the manipulation of the esophagus as well as of the stomach considering that both these organs are very rich in sensory end organs connected to the vagi. Supportive evidence for such a mechanism could be the fact that auricular fibrillation developed in two patients of this group in whom only palliative gastrostomy was performed without opening of the thorax. Rapid shift of the mediastinum did not appear to bear a relationship to the incidence of abnormal rhythms in the cases of Massie and Valle and could be implicated in only one of our 20 cases. It is however possible that all these factors may act in conjunction and lead to the development of postoperative arrhythmias in extracardiac thoracic surgery.

The frequent occurrence of auricular fibrillation after mitral commissurotomy in contrast to other types of cardiac surgery, has to be ascribed to other factors particularly related to mitral disease. Dilatation of the left atrium in mitral stenosis has to be considered in first place as a factor per se causing auricular fibrillation. In addition rheumatic activity could play a role but no correlation has been established between the finding of Aschoff bodies in the amputated auricular appendix and the development of auricular arrhythmias. Another factor could be reabsorptive processes in the auricular incision associated with edema and necrosis at this site which may occur in the postoperative period and this could account for the variable time period that precedes the onset of auricular fibrillation after mitral surgery.

In all of our cases surgical pericarditis preceded or was detected simultaneously with the onset of arrhythmia. However, no clear relationship between the two events could be established since in seven patients sinus rhythm persisted despite development of postoperative pericarditis. Furthermore, the high incidence of auricular fibrillation in mitral surgery is in marked contrast to its low incidence in postoperative pericarditis in other types of cardiac surgery. Thus, in no instance did auricular fibrillation occur after pulmonary valvotomy and this is in keeping with the experience of others. None of the above mentioned factors by itself appears adequate to explain all aspects of postoperative auricular arrhythmias.

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Number of Cases</th>
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<tbody>
<tr>
<td>Within 5 days</td>
<td>15</td>
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<tr>
<td>Within 5 to 10 days</td>
<td>1</td>
</tr>
<tr>
<td>Within 10 to 20 days</td>
<td>3</td>
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<tr>
<td>After 20 days</td>
<td>1</td>
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<tr>
<td>TOTAL</td>
<td>20</td>
</tr>
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</table>
mias in mitral stenosis but it is very likely that any of them, or the association of several such factors may act as a trigger in establishing a disturbance of rhythm in an atrium predisposed to it by disease.

Postoperative pericarditis. Pericardiotomy had been performed in all except one of our cases who developed pericarditis after surgery. The exception was a right pneumonectomy for bronchogenic carcinoma and here the pericarditis could be attributed to an inflammatory process secondary to abscess formation in the region of the carcinoma. Biocca et al\(^3\) reported postoperative ST-T alterations in a high percentage of pneumonectomies in which the pericardium had to be incised in order to ligate the vascular root. The changes of the S-T segment as reported by Danese et al\(^4\) were also, in all likelihood, secondary to pericarditis although no statement concerning pericardial incisions is made. Thus, from previous reports and our own experience it can be concluded that alterations of the electrocardiogram attributable to pericarditis can be anticipated in any case in which the pericardial sac was opened. This type of pericarditis seems to be directly related to surgical trauma.

Surgical pericarditis has been reported to have an early onset and to take a rapid course,\(^7\), \(^8\), \(^17\) apparently more rapid than in other types of pericarditis. In some of our cases characteristic electrocardiographic alterations were seen to develop within a few hours. While the electrocardiographic pattern may follow the classical course of evolution extending over a period of three to four weeks, it was not unusual to see rapid regression of the acute alteration and rapid restitution to the preoperative pattern within one or two weeks, without the appearance of intermediate stages consisting of flattening and inversion of T waves. In digitalized patients, as in most cases submitted to mitral surgery, the postoperative electrocardiogram appears to be altered by the simultaneous action of two partly opposed factors: pericarditis tends to elevate the S-T segment while digitalis tends to depress and to shorten its duration. The result is a particular configuration of the final deflection, almost characteristic for electrocardiograms recorded shortly after mitral comissurotomy (Figs. 1 and 2).

SUMMARY AND CONCLUSIONS

1. Postoperative arrhythmias and pericarditis in 55 patients who underwent thoracic or cardiac surgery have been studied in the electrocardiogram.

2. Auricular fibrillation or flutter were the most common arrhythmias and occurred early after operation. Late onset, more than 10 days after surgery, suggests serious postoperative complications or reactivation of the rheumatic process. Auricular fibrillation develops frequently after surgery for carcinoma of the esophagus and seems to be associated with a grave prognosis.

3. The most important factors in the development of postoperative auricular fibrillation appear to be the age of the patient and preexistent pathology of the atrial myocardium. Hypoxemia and/or vagal irritation may trigger the abnormal mechanism.
4. Surgical pericarditis has an early onset and may follow the usual or an abbreviated electrocardiographic course. An electrocardiographic pattern is described of acute pericarditis modified by digitalis effect, characteristically seen in the first days after mitral commissurotomy.

Acknowledgement: We wish to thank the members of the Surgical Staff of the Michael Reese Hospital for the opportunity to use their records in this study, and to Dr. Louis N. Katz for his valuable criticism and suggestions.

RESUMEN

1. Se han estudiado los electrocardiogramas de las arritmias postoperatorias y en las pericarditis de 55 enfermos que sufrieron operaciones de tórax incluyendo cardiacas.

2. La fibrilación auricular o el flutter fueron las arritmias más comunes y se presentaron pronto después de las intervenciones. El principio tardío, más de 10 días después de la operación, sugiere complicaciones postoperatorias serias o reactivación de un proceso reumático. La fibrilación auricular se desarrolla frecuentemente después de cirugía por carcinoma del esófago y parece que denota un pronóstico grave.

3. Los factores más importantes en el desarrollo de la fibrilación auricular parecen ser la edad del enfermo y la patología preexistente en el mio-cardio atrial. La hipoxemia y/o la irritación vagal pueden desencadenar el mecanismo anormal.

4. La pericarditis de origen quirúrgico tiene un principio temprano y puede seguir la evolución habitual o una evolución electrocardiográfica abreviada.

Son descritas las características de la pericarditis modificada por el efecto digitalico, caracteristicamente vistas en los primeros días después de la comisurotómia mitral.

ZUSAMMENFASSUNG

1. Postoperative Arrhythmien und Pericarditis wurden im EKG an 55 Patienten untersucht, die einer thorakalen oder cardialen Operation unterzogen worden waren.


REFERENCES