1956

Cardiac Arrhythmias following total Pneumonectomy

Arthur C. Miller

CARDIAC ARRHYTHMIAS

FOLLOWING

TOTAL PNEUMONECTOMY

ARTHUR C. MILLER, M. D.

[redacted]

THIS THESIS IS PRESENTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR
A MASTER OF SCIENCE DEGREE

TABLE OF CONTENTS

PREFACE II

INTRODUCTION 1

ANATOMY 2

PHYSIOLOGY 5

HISTORY 10

CLINICAL SURVEY 15

PROPHYLAXIS 19

CASE SERIES PRESENTATION 22

CASE REPORTS (Charts) 23

STATISTICAL ANALYSIS 30

ARRHYTHMIAS NOTED IN THESE CASES 31

ANALYSIS OF CAUSE OF DEATH 32

TREATMENT 33

SUMMARY AND CONCLUSIONS 37

BIBLIOGRAPHY 39

P R E F A C E

Since the birth of thoracic surgery many developments have taken place. With the solution of each problem, more real and potential problems have been encountered.

The purpose of this manuscript is twofold. First, to review the problem of cardiac arrhythmias following total pneumonectomy and to suggest possible etiology, possible prophylaxis, and definitive treatment. Secondly, to present a series of 95 consecutive pneumonectomies which have been reviewed from the standpoint of abnormal cardiac rhythms in the postoperative period. This patient review has not been previously presented.

I N T R O D U C T I O N

Arrhythmias are among the chief cardiac complications following total pneumonectomy. The incidence is sufficient that it can not be ignored.

In 1948, Currens, White and Churchill[1] reported a series of 56 patients who underwent surgery for carcinoma of the lung or esophagus in which 13 developed arrhythmias. Masse and Valle[2] in 1947, reported an arrhythmia incidence of 9.1% in their group of cases, and also noted the incidence to be 14.3% in cases over 35 years of age. Cale[3] in consulting with his department of anesthesia late in 1951, found that in 496 major intrathoracic operations, cardiac arrhythmias were noted in 11 cases. This number be compared with 525 cases of upper abdominal surgery in which arrhythmias were found in only 5 instances. Humphreys[4] reported that 32.4% of 34 pneumonectomy patients developed some type of arrhythmia.

A N A T O M Y

The heart is a hollow muscular organ which, in the adult, measures about 12 cm. in length, 8 - 9 cm. in breadth at the broadest part, and 6 cm. in thickness. Its weight varies from about 280 to 340 grams, ordinarilly being heavier in the male. There are four main cavities within the heart, namely, the right and left atria and the right and left ventricles.

The heart wall is covered by a serous layer of flat mesothelial cells, called the epicardium. It is lined by endocardium and between these two membranes is the muscular wall, or myocardium. This myocardium consists of bands of fibers which present an exceedingly intricate interlacement. They comprise, (a) the fibers of the ventricles, (b) the fibers of the atria, and (c) the atrioventricular bundle of His.

Microscopically, the fibers of the heart muscle differ a great deal from those of other striped muscles. They are about one-third smaller, and their transverse striae

are not well-marked. The figures are made up of distinct quadrangular cells, joined end to end, and each cell contains a clear oval nucleus which is situated near its center. At the extremities of the cells is a noted tendency to branch or divide, the subdivisions uniting with offsets from other cells, thus accomplishing an anastomosis of fibers. As far as has been determined no sarcolemma exists. The connective tissue between the bundles of fibers is considerably less than in ordinary striped muscle.

"Between the endocardium and the ordinary cardiac muscle are found, imbedded in a small amount of connective tissue, peculiar fibers known as Purkinje fibers. They are found in certain mammals and in birds, and can be best seen in the sheep's heart, where they form a considerable portion of the moderator band and also appear as gelatinous-looking strands on the inner walls of the atria and ventricles. They also occur in the human heart associated with the terminal distributions of the bundle of His. The fibers are very much

larger in size than the cardiac cells and differ from them in several ways. In longitudinal section they are quadrilateral in shape, being about twice as long as they are broad. The central portion of each fiber contains one or more nuclei and is made up of granular protoplasm, with no indication of striations, while the peripheral portion is clear and has distinct transverse striations. The fibers are intimately connected with each other, possess no definite sarcolemma, and do not branch."[5]

The heart muscle itself possesses the inherent property of contraction apart from any type of nervous stimulation. The more embryonic the muscle the better it is able to initiate and also propagate the contraction wave.

Now we wish to mention something more of the structures necessary for initiating and propagating the impulses through the heart. At the junction of the right atrium with the superior vena cava there is located the sinoatrial node. This is frequently called

the "pacemaker" of the heart. In this node fibers of the vagus and sympathetic nerves may easily speed or slow the heart rate. These node cells are modified cardiac muscle cells. In the muscular septum between the two atria is located the atrioventricular node. This node, also composed of modified muscle cells, represents the proximal end of a bundle of these special fibers called the atrioventricular bundle of His. In the septum it divides into right and left branches which finally reach the surface of the ventricular cavities and break into a meshwork of the fibers called the Purkinje system.

The Cardiac Impulse and Certain Controls of the Heart

Starting with sinoatrial node, or "pacemaker", the excitation wave spreads in all directions through the atria and reaches the atrioventricular node. From there, the wave travels the bundle of His, its branches and the Purkinje system to the ventricular muscle.

We know that the heart is able to beat

rhythmically after its complete separation from the central nervous system, but in the normal animal the automatic action is under the continuous influence of nervous impulses. This nervous mechanism comprises:

1) Groups of nerve cells in the medulla called the cardiac centers,

2) various afferent pathways along which impulses are conveyed to these centers from numerous regions of the body, and

3) the vagus and accelerator or augmentor nerves which transmit impulses from the centers to the heart. The vagus nerves are cardio-inhibitory. During normal life the vagus nerves exert a continuous restraint upon the action of the heart. The accelerator fibers belong to the thoracico-lumbar division of the autonomic, or involuntary, nervous system. It has been shown that to remove all accelerator influence from the heart, it is necessary to remove the stellate ganglia and to interrupt the connections as far down as the fourth or fifth thoracic ganglion.

We will not enter into a lengthy discussion of all the cardiac reflexes known to exist. It should be mentioned, however, that these are distinctly definite. "Under ordinary conditions, the activities of the cardio-inhibitory and cardio-accelerator centers which result in the continuous discharge of impulses along the corresponding cardiac nerves are in turn dependent to a very large extent, if not entirely, upon the reception of impulses by afferent paths. In other words, the maintenance of the tone of the centers, and so of the normal resting rate of the heart, and the alterations in rate which occur under various physiological conditions are in large measure either reflex in nature or due to impulses received from cerebral centers. The impulses which stream into the nervous centers arise in all parts of the body, the heart itself included. By these influences the tone of either center may be exalted or depressed, and corresponding changes produced in the cardiac rate".[6] For example, note the fairly well known oculo-cardiac reflex in which slowing of the

pulse can usually be induced by pressure upon the eyeball at the outer canthus. Afferent fibers are known to exist in the cardiac vagus itself. The receptors of these lie within the heart tissues and upon the aortic arch. A rise in the pressure of the blood entering the right auricle induces an increase in cardiac rate. This reflex was named after its discoverer, Bainbridge.

It is well known that numerous drugs act upon the cardiac rate. These include, atropine, muscarine, pilocarpine, physostigmine, acetylcholine, nicotine and others.

Known materials found in the circulating blood which influence the action of the heart include:

1) Calcium, potassium and sodium;
2) Adrenalin;
3) Oxygen; and
4) The acid metabolites, carbon dioxide and lactic acid.

Carbon dioxide exerts its effect directly upon the cardiovascular musculature as well as upon the cardiac and vasomotor centers.

Carbon dioxide and lactic acid, formed during the activity of muscle and other tissues, dilate the peripheral vessels, and the higher carbon dioxide tension in the venous blood return to the heart enhances the extensibility of the cardiac muscle fiber during diastole. Consequently, a favorable effect upon the filling of the heart is noted and the cardiac output is therefore increased.

It has been found that the junctional tissues are particularly sensitive to high tensions of carbon dioxide. Auriculo-ventricular conduction is markedly depressed when the carbon dioxide excess is such as to cause a fall in pH of the fluids bathing the cardiac muscle fibers. Heart block will occur when the pH reaches a level of around 7.0. Best and Taylor[6] have pointed out that continued exposure of the heart to a high CO_2 tension causes weakening of the beat and the development of irregular rhythms.

The output of the heart is reduced slightly by high tensions of oxygen, and is increased

slightly by low oxygen tension. The heart rate is increased in the early stages of oxygen lack. In the later stages of anoxemia, arrhythmias develop and heart failure supervenes. The heart muscle itself is unable to contract any considerable oxygen debt.

HISTORY

The fact that arrhythmias do occur following thoracic surgery, and more notably following total pneumonectomy, is not new. However, no great amount of literature has been produced on the subject. In 1943 Bailey and Betts[7] reported on 78 patients who had received total pneumonectomy. Of this number eight developed either auricular fibrillation or auricular flutter. None of these patients had evidence of heart disease. Friedlander and Levine[8] back in 1934 reported that auricular fibrillation and auricular flutter can occur without evidence of organic heart disease. In 1936, Orgain, Wolff, and White[9] further reported on the occurrence of uncomplicated auricular fibrillation and auricular flutter. They

commented on its frequent occurrence and good prognosis in patients without evidence of cardiac disease. Bailey and Betts[7] went on to speculate as to the etiology of the arrhythmias following pneumonectomy. In two of their eight cases a moderate rise in fever was noted at the time the arrhythmia began. Only one patient remained afebrile at the time of the arrhythmia. The hypothesis suggested was that the precipitating factor was vagal irritation from a stitch abscess or infection of the bronchial stump in the presence of hyperexcitability of the auricular muscle resulting from marked displacement of the mediastinum.

Among the twelve cases reported by Currens, White, and Churchill[1], were eight cases of auricular fibrillation and four of auricular flutter. They stated that age seems to be a predisposing factor, since they had noted that arrhythmias seldom occurred following thoracic surgery in patients below the age of forty years.

In 1944 Smith and Wilson[10] reported on some important investigative work on the

relationship of anoxemia of the auricles and vagal stimulation (mecholyl effect) in the hearts of dogs. "In the normally beating heart it was found that:

1) anoxemia apparently renders the heart more sensitive to the action of mecholyl;
2) auricular fibrillation frequently occurs spontaneously, or is easily induced by minute, mechanical, auricular stimuli after small doses of mecholyl during anoxemia;
3) reoxygenation of the blood results in the restoration of normal cardiac mechanism.

In another series of experiments, the factor of auricular distension was eliminated by perfusing the coronary vessels of the heart while the heart was beating empty; the administration of mecholyl also produced auricular fibrillation in hearts with acute, experimental 'mitral stenosis' ".

Searching also for specific etiology, Massie and Valle[2] stated that apart from the factor of age, the reason for the high incidence of arrhythmias following pneumonec-

tony could not be definitely determined. Their suggestion was that anoxemia and vagal stimulation may act synergistically in the production of the abnormal cardiac rhythms.

The impression gathered from the literature involving clinical cases is that the combination of vagal stimulation in the presence of anoxia is the single most important factor in the etiology of these arrhythmias. The work of Nahum and Hoff [11] in the experimental laboratory lends support. In the experimental animal they were able to produce auricular fibrillation by stimulating the vagus nerve. However, and this is extremely important, they were able to do this only during anoxia. It is known that cardiac arrhythmias are more apt to be noted with the use of certain anesthetic agents. Eisaman, Caylor, Jackson and Roe [12] reported statistical data on the incidence of arrhythmias induced during 334 major surgical cases. In the cases involving the use of cyclopropane 62% had some type of arrhythmia. The multiple and multi-

focal ventricular premature contractions were the most frequent and dangerous arrhythmia. The comparative group received penthothal (Abbott) nitrous oxide and ether. Only 9% of these cases had some type of arrhythmia. In this group the auricular arrhythmias were more common.

The question of trauma as an etiologic factor is always intriguing. Taylor[13] stated in 1953 that, "transient cardiac arrhythmias induced by non-penetrating trauma to the chest has been reported only rarely, - an extensive review of the literature revealed only 17 cases followed by apparently complete recovery. It is quite probable that the reported cases represent only a fraction of the true incidence and that increasing awareness of the possibility coupled with more common use of the electrocardiograph will detect cases more frequently." He thinks that the transient arrhythmias are probably due to contusion of the right auricle in the region of the conduction system being occasioned by compression of the heart against the liver at the right pericardiophrenic angle..

CLINICAL SURVEY

In attempting to obtain more information regarding etiology, prophylaxis, and treatment of cardiac arrhythmias following total pneumonectomy I conducted a survey in the form of a brief questionnaire. The men contacted in this survey included recognized men in the field of thoracic surgery, anesthesiology and cardiology. A fairly wide geographical area was sampled as evidenced by the fact that answers were received from Boston, New York, Washington, D.C., Philadelphia, Detroit, St. Louis, Ann Arbor, Madison, Wisconsin, Portland, Oregon, Seattle, San Francisco and Los Angeles.

The answers received regarding the etiology of these arrhythmias were so varied that no one cause received a majority vote. However the etiological possibilities mentioned included the following factors listed according to the frequency of mention in the replies received.

1) Reflexes, vagal.

2) Cardiac anoxia.

3) Medication, including anesthesia.

   Type and amount.

4) Direct trauma.

5) Intrathoracic tension and mediastinal shift.

6) Extra cardio-respiratory factors such as thyroid, adrenal, psychic, etc.

7) Increased carbon dioxide levels.

8) Pulmonary hypertension.

9) Pre-existing heart disease.

Burford[14] in rendering an opinion stated that "I am not at all sold on the idea of so-called 'vago-vagal reflexes'. I doubt very much that pulmonary, hilar or cardiac manipulation will ever produce cardiac arrest or arrhythmia when the myocardium of that organ is properly oxygenated and when the carbon dioxide levels are being maintained at a normal level." Bailey[15] felt strongly that postoperative arrhythmias following pneumonectomy are due to pulmonary hypertension associated with ligation of one of the main arteries.

The following is an attempt to list the factors which can probably be considered as being able to produce cardiac arrhythmias, some singly, and some obviously in combination with other listed and unlisted factors:

1) Vagal stimulation:
   a) Direct trauma
   b) Indirect trauma
   c) Infection
2) Cardiac anoxia
3) Increased carbon dioxide levels.
4) Direct trauma to the heart.
5) Medication.
6) Anesthetic agents.
7) Thyrotoxicosis.
8) Pre-existing heart disease.
9) Adrenal disease.
10) Intrathoracic tension and mediastinal shift.
11) Pulmonary hypertension.
12) Psychic trauma.
13) Infection.
14) Fever.
15) Hemorrhage.

It is my opinion that the most important factors in the etiology of cardiac arrhythmias in postpneumonectomy patients are cardiac anoxia, and increased carbon dioxide levels. One of these conditions plus mechanical stimulation of the myocardium either directly or through nerve reflexes provides a formal invitation to cardiac arrhythmias.

PROPHYLAXIS

The question of prophylaxis was also surveyed, and as consistency would demand, the answers to the problem consisted chiefly of measures to combat the respective factors suspected under etiology.

Bailey[14] feels that the use of blood transfusions during pneumonectomy contributes to the problem of arrhythmias by adding to the increase in pulmonary blood pressure which results from pneumonectomy. No others in the survey discussed this situation.

There were very decided differences of opinion

regarding anesthetic agents.

Nearly all of the men questioned were definitely against the use of digitalis preoperatively in cases without evident heart disease. The prophylactic use of quinidine sulfate preoperatively was suggested by several.

A careful preoperative work up should be done on all patients scheduled for elective pneumonectomy. This study should include careful evaluation of the cardiovascular system and the pulmonary function. The patient's endocrine system should be considered at least to the extent that no evidence of thyroid or adrenal malfunction be found to exist. Anemia should be corrected. We also examine for the presence of subclinical uremia, gross diminution of blood volume, and hypoproteinemia.

We prefer to have the anesthesiologist order the preoperative medication. It may be needless to say, but it is important to remember, that adequate oxygenation is imperative from the start of anesthesia onward.

All measures indicated to prevent shock should be available and used when necessary. The use of oxygen in the immediate post-operative period is routine with our cases. It is usually discontinued in about twenty-four hours, but may be continued longer if tachypnea, dyspnea, tachycardia, or cyanosis is noted.

It is important at the end of the operation to adjust the intrapleural pressure on the operative side, unless a water-seal drainage tube has been used.

INITIAL REPORT OF NINETY-FIVE CONSECUTIVE CASES OF PNEUMONECTOMY

These cases will be arranged in a table, listing in sequence:

1) Patient's initials
2) Age
3) Sex
4) Diagnosis
5) Left or right sided procedure
6) Anesthetic agent used
7) Total operating time
8) Result

Most of the cases were operated by the resident staff at Herman Kiefer Hospital, Detroit, Michigan. As will be noted most of the pneumonectomies were for far advanced pulmonary tuberculosis with cavitation. It is well known that pulmonary resections are frequently the most difficult in this condition.

In the following charts, the abbreviation "F.A.T.B.(Cav)" means "far advanced pulmonary tuberculosis with cavitation". "P-C-P" stands for "Pentothal-Curare-Procaine". "E.V." is used for "Vinyl ether".

	INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
1)	A.B.	41	M	F.A.T.B.(Cav)	Rt.	P-C-P	2:18	None	L
2)	C.S.	7	F	F.A.T.B.(Cav)	Rt.	Ether-Oxygen	2:25	None	L
3)	E.B.	27	F	F.A.T.B.(Cav)	Rt.	P-C-P	2:17	None	L
4)	J.M.	20	F	F.A.T.B.(Cav)	L.	P-C-P	3:10	None	L
5)	E.N.	24	F	F.A.T.B.(Cav)	L.	P-C-P	2:48	None	L
6)	E.C.	26	F	F.A.T.B.(Cav)& Bronchiectasis	L.	P-C-P	2:27	None	L
7)	J.M.	48	M	F.A.T.B.(Cav)	L.	P-C-P	3:30	Prem.Aur.Syst. (18 Day PO)	L
8)	H.R.	41	M	F.A.T.B.(Cav)	L.	P-C-P	3:20	None	L
9)	A.H.	54	F	F.A.T.B.(Cav)	L.	P-C-P	2:45	None	L
10)	A.B.	43	M	Chr. Supp. Pneum.	Rt.	P-C-P	3:15	None	L
11)	J.D.	40	M	F.A.T.B.(Cav)	L.	P-C-P	?	None	L
12)	C.F.	32	M	F.A.T.B.(Cav)	L.	P-C-P	3:20	None	L
13)	M.M.	44	M	Carcinoma	L.	P-C-P	3:29	None	L
14)	W.M.	62	M	Adenocarcinoma	L.	P-C-P	3:20	None	L
15)	E.H.	45	M	Chr. Supp. Pneum.	Rt.	P-C-P	2:24	None	L
16)	P.D.	50	M	F.A.T.B.	Rt.	N20-E.V.	2:33	None	L
17)	J.S.	56	M	Carcinoma	Rt.	P-C-P	2:44	None	L

INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
18) W.K.	56	M	F.A.T.B.(Cav) & Diabetes	L.	P-C-P	2:58	None	L
19) T.C.	50	M	F.A.T.B.(Cav)	L.	Pent.N2O-E.V.	4:01	None	L
20) G.R.	50	F	F.A.T.B.(Cav)	L.	P-C-P	3:30	None	L
21) O.K.	49	M	F.A.T.B.	L.	P-C-P	2:44	None	L
22) V.C.	37	F	F.A.T.B.(Cav)	Rt.	P-C-P	3:19	None	L
23) P.M.	17	F	F.A.T.B.(Cav)	Rt.	P-C-P	2:45	None	L
24) C.P.	65	M	Carcinoma	Rt.	P-C-P	?	None	L
25) H.C.	49	M	Silicosis,anthracosis, Prod. TB(Cav) &caseation,Caseous TB,pleuritis	Rt.	P-C-P	4:16	None	L
26) C.L.	50	M	F.A.T.B.(Cav)	Rt.	N2O-E.V.	4:27	None	D
27) E.S.	40	F	F.A.T.B.	Rt.	P-C-P	3:32	None	L
28) G.C.	29	M	F.A.T.B.(Cav)	Rt.	P-C-P	3:20	None	L
29) W.L.	63	M	Bronchiectasis, anthracosis, organizing pneumonitis	Rt.	P-C-P	3:12	None	L
30) J.M.	54	M	F.A.T.B.(Cav)	L.	P-C-P	3:50	None	L
31) L.B.	38	M	Chr. Supp. Dis.	L.	P-C-P	3:25	None	L
32) S.K.	54	M	Carcinoma	Rt.	P-C-P	4:00	None	L
33) R.Y.	29	F	F.A.T.B.	L.				L

INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
34) L.J.	52	M	F.A.T.B.(Cav)	Rt.	P-C-P	4:39	None	L
35) M.B.	53	M	F.A.T.B.(Cav)	L.	P-C-P	4:35	None	L
36) W.D.	42	M	Bronchiectasis	Rt.	P-C-P	3:43	None	L
37) L.H.	55	F	F.A.T.B.(Cav)with stenosis & ulceration;also malig. hypertension, retinitis, nephrosclerosis.	Rt.	P-C-P	2:20	None	L
38) I.O.	43	M	Carcinoma	L.	P-C-P	4:05	None	L
39) S.D.	26	F	F.A.T.B.(Cav)	L.	P-C-P	2:54	None	L
40) A.J.	36	M	F.A.T.B.(Cav)	Rt.	P-C-P	4:30	None	L
41) A.C.	48	M	Carcinoma with Abs.	L.	P-C-P	2:33	None	L
42) R.P.	39	M	F.A.T.B. with Bronchiectasis	L.	P-C-P	2:08	None	L
43) J.B.	54	M	F.A.T.B.	L.	Vin.Ether	1:45	None	L
44) A.K.	29	F	F.A.T.B.(Cav)	Rt.	P-C-P	2:22	None	L
45) F.Z.	54	M	T.B.Bronchiectasis	L.	P-C-P	3:00	None	L
46) D.D.	24	F	F.A.T.B.(Cav)	L	P-C-P	2:03	None	L
47) G.R.	33	M	F.A.T.B.(Cav)	L	P-C-P	3:31	None	L
48) J.C.	25	F	F.A.T.B.(Cav)	L	P-C-P	2:37	None	L
49) A.A.	22	F	F.A.T.B.(Cav)	L	P-C-P	2:05	None	L

	INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
50)	E.M.	50	M	F.A.T.B.(Cav)	Rt.	P-C-P	3:25	None	L
51)	M.B.	26	F	F.A.T.B.(Cav)	L.	P-C-P	5:00	None	L
52)	L.M.	39	F	F.A.T.B.(Cav) & Briess.	L.	P-C-P	3:07	None	L
53)	W.G.	54	M	F.A.T.B.	Rt.	P-C-P	3:04	None	L
54)	F.G.	38	F	F.A.T.B.(Cav)- Endo.Br.Dis.	L.	P-C-P	3:31	None	L
55)	S.G.	26	F	F.A.T.B.(Cav)	L.	P-C-P	2:30	None	L
56)	R.N.	43	F	F.A.T.B.(Cav)- Endo.Br.Dis. with stenosis & Ulceration.	Rt.	P-C-P	4:02	None	L
57)	R.P.	45	F	F.A.T.B.-T.B.- Bronchiectasis with Ulceration.	L.	P-C-P	2:37	None	D
58)	E.B.	40	F	F.A.T.B.(Cav)- T.B. Endobr.	Rt.	P-C-P	3:51	None	L
59)	C.T.	47	F	F.A.T.B.(Cav) & Diabetes	Rt.	P-C-P	3:30	None	D
60)	T.D.	22	M	F.A.T.B.	Rt.	P-C-P	2:40	None	L
61)	M.J.	22	F	F.A.T.B.	L.	P-C-P	2:00	None	L
62)	B.C.	34	M	F.A.T.B.(Cav)	L.	P-C-P	1:35	None	L

INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
63) H.I.	44	M	F.A.T.B.	L.	P-C-P	1:50	None	L
64) B.W.	30	M	F.A.T.B.(Cav)	Rt.	P-C-P	4:30	None	D
65) M.R.	23	F	Chr.Supp.Dis.	Rt.	P-C-P	2:40	None	L
66) A.J.	27	M	F.A.T.B.	L.	P-C-P	2:34	None	L
67) A.P.	49	M	F.A.T.B.(Cav)	L.	P-C-P	3:05	None	L
68) O.F.	28	F	F.A.T.B.(Cav)	L.	P-C-P	3:34	None	L
69) B.B.	19	F	F.A.T.B.(Cav)	L.	P-C-P	2:10	None	L
70) D.C.	37	M	F.A.T.B.(Cav)	L.	P-C-P	3:50	18 Days had Aur. Fib. for 3 Days, digitalized.	L
71) S.E.	41	F	F.A.T.B.(Cav)	Rt.	P-C-P	3:17	None	L
72) S.L.	30	F	F.A.T.B.	L.	P-C-P	4:12	None	L
73) D.B.	25	F	F.A.T.B.(Cav)	L.	P-C-P	1:34	None	L
74) P.G.	29	M	F.A.T.B.(Cav)	L.	P-C-P	1:38	None	L
75) R.C.	59	M	Carcinoma	L.	P-C-P	2:39	None	L
76) A.T.	46	M	Carcinoma	Rt.	P-C-P	4:35	None	L
77) J.C.	51	M	Carcinoma	L.	P-C-P	3:18	None	L
78) B.C.	35	M	Bronchiectasis	L.	P-C-P	2:13	None	L

INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
79) C.K.	57	M	Chr.Supp.Dis. (Hist.Hypertension)	Rt.	P-C-P	3:31	Aur.Fib. 4 Days PO,lasting 1 Day. Rx-Quinidine B.P. 210/120	L
80) W.B.	46	M	Bronchiectasis	Rt.	P-C-P	2:30	None	L
81) J.P.	43	M	Carcinoma	L.	P-C-P	2:37	None	L
82) J.O.	61	M	Chr.Supp.Dis. & Abscess	L.	P-C-P	4:25	None	L
83) F.G.	44	M	F.A.T.B.	L.	P-C-P	3:13	Sl. Irreg. First PO Day	D
84) R.L.	46	M	F.A.T.B.(Cav)	Rt.	P-C-P	3:11	5 days PO, aur. fib. noted. Had digitalis Pre-op.	D
85) G.T.	23	F	Chr.Supp.Dis	L.	P-C-P	2:28	None	D
86) C.H.	41	M	Carcinoma	Rt.	P-C-P	3:35	None	L
87) H.T.	55	M	Bronchiectasis & Ves. Emph.	L.	P-C-P	2:27	None	L
88) R.H.	36	F	F.A.T.B.- Empyema	Rt.	P-C-P	3:23	None	L
89) E.M.	46	F	F.A.T.B.(Cav)	Rt.	P-C-P	2:35	None	L
90) C.M.	58	F	F.A.T.B. - Empyema	Rt.	P-C-P	3:33	None	L

INITIAL	AGE	SEX	DIAGNOSIS	SIDE	ANESTHETIC	DURATION	P.O.ARRHYTHMIA	RESULT
91) M.C.	19	F	F.A.T.B.	Rt.	P-C-P	2:25	None	L
92) S.S.	25	F	F.A.T.B.(Cav)	L.	P-C-P	1:28	None	L
93) E.B.	27	F	F.A.T.B.(Cav)	L.	P-C-P	2:02	None	L
94) B.R.	40	F	F.A.T.B.(Cav)	L.	P-C-P	2:45	None	L
95) H.H.	49	M	Carcinoma	Rt.	P-C-P	2:15	None	L

BRIEF ANALYSIS OF THE PREVIOUS CHARTS:

Total cases	95
Mortality rate (Death within 8 weeks)	7.3%
Right pneumonectomy	10.0%
Left pneumonectomy	5.4%
Number of male patients	55
Number of female patients	40
Number of male deaths	4
Number of female deaths	3
Average age of patient	40 Years
Average age of patients developing arrhythmias	46 Years
Mortality rate of patients developing arrhythmia	40.0%
Average duration of operation	3 Hours

INDICATIONS FOR SURGERY:

Far advanced pulmonary tuberculosis	64
Chronic suppurative pneumonitis	7
Bronchiectasis	5
Tumor	14

THE ARRHYTHMIAS NOTED IN THESE CASES

1) One case developed premature auricular contractions on the eighteenth day post-operative. This development was short lasting, and subsided without treatment.

2) Another patient developed auricular fibrillation on the eighteenth post-operative day. Digitalis was used and normal rhythm returned on the 21st postoperative day.

3) Auricular fibrillation was noted in one patient on the fourth postoperative day. This lasted one day. Quinidine was used in the treatment.

4) The only record in another case was that the patient had a slight irregularity in his cardiac rhythm during the first postoperative day. No special treatment was used. He died on the sixth day.

5) One case, a 46 year old man who had been given digitalis preoperatively, developed an auricular fibrillation on the fifth postoperative day. He died on the ninth day.

ANALYSIS OF CAUSE OF DEATH

Death occurred in from 1 - 17 days postoperatively.

Total deaths	7
Inadequate cardio-respiratory reserve	3
"Cor Pulmonale"	1
Hemorrhagic shock	1
Massive pulmonary embolism	1
Acute right heart dilatation (This patient had old mitral stenosis with insufficiency.)	1

TREATMENT

Thus far we have mentioned nothing regarding the treatment of arrhythmias following total pneumonectomy. The men questioned in the survey felt that the treatment of these arrhythmias was essentially the same as for the treatment of a similar type arrhythmia in a non-surgical case.

In considering atrial fibrillation White[16] says, "The tachycardia rather than the arrhythmia is the serious factor and if that is reduced to a normal heart rate the circulation may be maintained in a satisfactory way in spite of the irregularity. The fact, however, that the circulation is more efficient with normal rhythm than with atrial fibrillation at the same heart rate makes it often worthwhile to attempt the restoration of normal rhythm, for there may come a time in an individual case when the more economic circulation maintained by normal rhythm means the difference between cardiac sufficiency and cardiac failure."

Prinzmetal and Kennamer [17] remarked in 1954

that, "The majority of cardiac arrhythmias can be controlled by proper use of the digitalis glucosides, quinidine, procaine amide (Pronestyl), carotid sinus massage, and sedation. Since the clinical severity of an arrhythmia is usually proportional to the disturbance in ventricular rate, emergency treatment is designed to normalize this rate even though the arrhythmia persists."

For the postoperative arrhythmias which are usually either atrial fibrillation or atrial flutter, we prefer to depend on the use of digitalis with or without the use of quinidine. Of the purified digitalis preparations, lanatoside C (Cedilanid Sandoz) is one of the most widely used in this country. It acts rapidly and is quickly eliminated. This drug may be used either intramuscularly or intravenously. The full digitalization dose is usually about 6 - 8 cc, or 1.2 to 1.6 mg. Ordinarily divided doses are given; such as giving 1.2 mg. or, 6 cc initially, followed, if necessary, in one hour by 0.4 mg. or, 2 cc.

Of course, other purified digitalis preparations

may be used, but we usually prefer Cedilanid. At times this preparation will control both the rate and the rhythm. If, however, the rhythm continues to remain irregular after full digitalization we use quinidine in addition.

Quinidine has been called the "broad spectrum" drug for use in disorders of rhythm. It has been used effectively in the prevention and termination of atrial fibrillation, atrial flutter, atrial extrasystoles, paroxysmal supraventricular tachycardia, paroxysmal ventricular tachycardia, and ventricular extrasystoles. The only absolute contraindication to the use of this drug is a history of a serious reaction, such as thrombocytopenic purpura, occurring during previous administration of the drug. Also, it should not be used in patients with complete atrioventricular heart block. This drug is generally administered by mouth. It is quickly and almost completely absorbed from the gastrointestinal tract. Quinidine sulfate is available in 0.1, 0.2, and 0.3 gm. tablets. Solutions of quinidine gluconate and quinidine hydrochloride are available

for parenteral use. According to Linenthal [18], "An initial dose of 0.2 to 0.6 gm. of quinidine sulfate is commonly used to terminate an arrhythmia, the larger amount being used in the more urgent situation. In most cases, doses are repeated at intervals of about two hours; this permits observation of the maximum beneficial and untoward effects of each dose. When a more rapidly increasing action is required, the drug may be given every hour, but one must accept the greater risk of untoward effects." Since quinidine is rapidly eliminated from the body, long continued administration carries no danger of cumulative toxicity, and the drug has been used prophylactically for years without ill effects. Now, if normal sinus rhythm has not been restored after three or four equal, two hourly doses, the size of the dose is increased by 0.1, or 0.2 gm. This dosage is then given three or four times at two hourly intervals before it is increased further.

During the treatment of the arrhythmia, it is still important to do all to combat anoxemia. Any obvious conditions thought to provoke or promote the arrhythmia should be corrected if at all possible.

SUMMARY AND CONCLUSIONS

In summarizing the data that has been presented in the foregoing pages, I feel that sufficient information has been presented that the following list of statements contain more than just the aroma of truth.

1) The incidence of cardiac arrhythmias following total pneumonectomy is greater than that following most surgical operations.

2) It is important to recognize this complication early and treat it.

3) This complication has an unfavorable effect on prognosis of the patient.

4) Anoxemia, elevated carbon dioxide levels, and mechanical stimulation of the myocardium directly or through nerve reflexes probably answer most of the question of etiology.

5) The patient over 40 years of age is more apt to develop a postoperative arrhythmia.

6) A thorough preoperative study of the patient is important.

7) Adequate oxygenation during the period of anesthesia is very important.

8) The medical treatment of an arrhythmia developing following pneumonectomy is essentially the same as the treatment of a similar arrhythmia occurring in a non-surgical patient.

BIBLIOGRAPHY

1) Currens, J.H., White, P.D., and Churchill, E.D.: Cardiac Arrhythmias Following Thoracic Surgery, N. Eng. J. Med. 229:360, Aug., 1943.

2) Massie, E., and Valle, A.R.: Cardiac Arrhythmias Complicating Total Pneumonectomy, Ann. Int. Med. 26:231-239, Feb., 1947.

3) Gale, J.W.: Personal communication.

4) Humphreys, P.C.: Bulletin Moore-White Med. Foundation 2:46-51,Sept.,1951.

5) Gray, Henry,: Anatomy of the Human Body, Lea and Febiger, Philadelphia,1950.

6) Best, C.H., and Taylor, N.B.: The Physiological Basis of Medical Practice, Fifth Edition, Williams and Wilkens, Baltimore, 1950.

7) Bailey, C.C., and Betts, R.H.: Cardiac Arrhythmias Following Pneumonectomy N. Eng. J. Med. 229:356-359, Aug.,1943.

8) Friedlander, R.D., and Levine, S.A.: Auricular Fibrillation and Flutter without Evidence of Organic Heart Disease, N. Eng. J. Med. 211:624-629, Oct. 2, 1934.

9) Orgain, E.S., Wolff, L., and White, P.D.: Uncomplicated Auricular Fibrillation and Auricular Flutter; Frequent Occurrence and Good Prognosis in Patients Without Other Evidence of Cardiac Disease. Arch. Int. Med. 57:493-513, March, 1936.

10) Smith, J.R., and Wilson, K.S.: Studies on the Production and Maintenance of Experimental Auricular Fibrillation, Amer. Heart. J. 27:176, Feb.,1944.

11) Nahum, L.H., and Hoff, H.E.: Auricular Fibrillation in Hyperthyroid Patients; Produced by Acetyl-B-Methylcholine Chloride, with Observation on Role of Vagus Nerves and Some Exciting Agents in Genesis of Auricular Fibrillations, J.A.M.A. 106:254-257, 1936.

12) Eisaman, J.L., Caylor, H.D., Jackson, C.E., and H.Roe:Cardiac Arrhythmias During Anesthesia, Amer. J. Surg. 86:23-28, July, 1953.

13) Taylor, H.B.: Transient Cardiac Arrhythmias Induced by Non-Penetrating Trauma to the Chest, Amer. Heart J. 46:557-564, Oct., 1953.

14) Burford, Thomas H.: Personal communication.

15) Bailey, Charles P.: Personal communication.

16) White, Paul D.: Heart Disease, The Macmillan Company, New York, 1956.

17) Prinzmetal, M., and Kennamer, R.: Emergency Treatment of Cardiac Arrhythmias, J.A.M.A. 154:1049-1054, Mar.,1954.

18) Lindenthal, A.J.: The Use of Quinidine in the Treatment of Cardiac Arrhythmias, Mod. Concepts of Cardiovascular Disease 20:299-301,Nov.,1955.