Disseminated Nodular Pulmonary Ossification in Patients with Mitral Stenosis

By William R. Wilson, M.D., Rikuro Sasaki, M.D., and Charles A. Johnson, M.D.

What seem to be rare complications of common diseases may merely be uncommon because no one accumulates a large number. The unusual combination of disseminated nodular bone formation in the lungs and chronic mitral stenosis is more common in young men. The clinical findings in 4 cases are described and the pathogenesis is discussed.

In recent years clinicians have had to think of histoplasmosis as well as tuberculosis when confronted with diffuse nodular calcific shadows in the lung parenchyma. Disseminated bone formation in the lung is rare, though a form associated with mitral stenosis has been recognized for many years. It is our purpose to review our experience with 4 cases of disseminated bone formation in mitral stenosis, to review autopsy-proved case reports, and to discuss the controversial question of pathogenesis.

The combination of pulmonary ossification and mitral stenosis occurs primarily in young men from 21 to 40 years of age. The predominance of men is remarkable considering the more frequent occurrence of mitral stenosis in women. Presenting symptoms and major physical signs are merely those accompanying ordinary mitral stenosis. Invariably congestive failure has occurred during the course of the disease. Hemoptysis is an infrequent presenting symptom, although a few patients radiologic examination shows the characteristic findings of mitral stenosis and many have had severe pulmonary hemorrhage dense opacities throughout the lung fields.

The apices are usually clear and the opacities are more numerous in the right lung field, especially in the lower lobe. Similar x-ray findings can be seen in severe pulmonary hemosiderosis.1-4 The radiologic differentiation is often quite difficult. Other opacities that must be considered include those of miliary tuberculosis, histoplasmosis, pneumoconiosis, arteritis, sarcoidosis, metastatic carcinoma, aspergillosis, bilharziasis, bronchopneumonia, bronchitis obliteratorans, chronic passive congestion, polycythemia, brucellosis, tularemia, psittacosis, leukemia, Hodgkin's disease, lupus erythematosus, and xanthomatosis.

The results of cardiac catheterization have been reported in a few patients. Moderate to severe pulmonary hypertension and increased pulmonary vascular resistance were found.5

Gross pathologic characteristics are the numerous granular, yellow to white, discrete nodules of bony consistency, usually measuring 2 to 8 mm. in diameter. The nodules are scattered throughout both lung fields, but often are concentrated near the pleura in the lower lobes. These nodules are distinctly different from diffuse forms of bone formation in the lung, such as the variety occasionally seen in old men, which is thought to come from metaplasia resulting from senile alterations in the perivascular connective tissue.6 Branching or racemose spicules of bone run into the septum of the lung, often for some

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distance. This process usually is more localized than the nodular type associated with mitral stenosis. In addition to nodular ossification, various pulmonary complications of mitral valve disease, such as congestion, induration, hemorrhage, or infarction, often occur.

The bony nodules vary in size. Usually they are round or mulberry-shaped. Characteristically they begin within alveoli or alveolar sacs. The larger nodules, often 6 to 8 mm. in diameter, overlap several adjacent air spaces. Osteocytes and small vascular channels can often be seen. Osteoid tissue and some osteoblasts usually are found in the periphery of the bony nodules. Elkeles and Glynn found that the framework of the lung was incorporated in the developing bone. Stains for elastic tissue demonstrated the continuity of the elastic tissue of the lung with that in the bone. The nodules are not adherent to the alveolar walls in the majority of cases. The pathologist often has difficulty in obtaining satisfactory sections showing the ossification because the nodules of bone are shelled out so easily.

Microscopic examination of the lungs usually reveals marked congestion, patchy increase in interstitial connective tissue, particularly in the perivascular areas, and numerous hemosiderin-containing macrophages in the alveoli, bronchial lumina, and interstitial spaces. In some areas the macrophages are arranged in small clusters. An exudate of homogeneous fibrinoid material in various stages of organization may be seen in the alveoli. No evidence of calcification can be found in the lungs in contrast to pulmonary alveolar microlithiasis, in which calcification is the main finding, and bone formation is rare.8-10

We were able to find only 23 cases adequately documented by autopsy or lung biopsy (table 1). Other cases have been reported on the basis of radiologic examination, but lacked pathologic confirmation.1,15,22-26 Only 3 confirmed cases were found in the American literature.14,15,21

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**Table 1.—Clinical Data of Documented Cases**

<table>
<thead>
<tr>
<th>Author, Year, Method of Verification</th>
<th>Year</th>
<th>Sex</th>
<th>Age</th>
<th>History of Rheumatic Fever</th>
<th>Other Valvular Lesions</th>
<th>Method of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagner11 1859 F</td>
<td>M</td>
<td>26</td>
<td>No</td>
<td>Tricuspid stenosis</td>
<td>Aortic insufficiency</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Derischanoff12 1930 M</td>
<td>M</td>
<td>21</td>
<td>No</td>
<td>Mitral insufficiency</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Salinger13 1932 M</td>
<td>F</td>
<td>31</td>
<td>No</td>
<td>None</td>
<td>None</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Wells and Dunlap14 1934 F</td>
<td>F</td>
<td>34</td>
<td>No</td>
<td>None</td>
<td>None</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Grishman and Kane15 1945 M</td>
<td>M</td>
<td>29</td>
<td>Yes</td>
<td>Mitral insufficiency</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Elkeles and Glynn7 1946 M</td>
<td>M</td>
<td>32</td>
<td>No</td>
<td>Aortic insufficiency</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Elkeles8 1947 M</td>
<td>M</td>
<td>32</td>
<td>No</td>
<td>None</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Lawson17 1949 F</td>
<td>M</td>
<td>39</td>
<td>Yes</td>
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<td>Autopsy</td>
<td>Autopsy</td>
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<tr>
<td>Steiner and Goodwin18 1954 F</td>
<td>F</td>
<td>32</td>
<td>No</td>
<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td>Haubrich19 1954 F</td>
<td>M</td>
<td>24</td>
<td>Yes</td>
<td>None</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td>WILSON, SASAKI, JOHNSON 1955 M</td>
<td>M</td>
<td>30</td>
<td>Yes</td>
<td>Mitral insufficiency</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Whitaker, Black, and Warrack20</td>
<td>M</td>
<td>27</td>
<td>No</td>
<td>None</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td>Daugavietis and Mautner21 1957 M</td>
<td>M</td>
<td>30</td>
<td>Yes</td>
<td>Mitral insufficiency</td>
<td>Autopsy</td>
<td>Autopsy</td>
</tr>
<tr>
<td>Fleming and Robinson5 1957 M</td>
<td>M</td>
<td>24</td>
<td>Yes</td>
<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>30</td>
<td>No</td>
<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>40</td>
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<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>34</td>
<td>No</td>
<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>35</td>
<td>No</td>
<td>f</td>
<td>Biopsy</td>
<td>Biopsy</td>
</tr>
</tbody>
</table>
The hospital records of 533 patients with mitral stenosis, with or without mitral insufficiency or aortic valve disease, seen from 1952 to 1958, were reviewed. In addition, autopsy protocols of the 175 cases of mitral stenosis from 1935 to 1952 were surveyed. Three instances of nodular bone formation in the lungs were discovered. The fourth example is of a man who recently had a mitral commissurotomy and lung biopsy.

**Case Reports**

**Case 1.** D. H., a 30-year-old taxi driver, was first seen in University Hospitals in January 1943 at the age of 28. The cardiac diagnosis was rheumatic mitral stenosis with congestive heart failure. An x-ray of the chest revealed multiple "calcific densities" measuring up to 1 cm. in diameter, cardiac enlargement, and a contour consistent with mitral stenosis (fig. 1). Initially, these densities were thought to represent old healed disseminated tuberculosi. Digitalis and diuretics produced temporary improvement, but death, due to severe congestive heart failure and acute bronchopneumonia, occurred in January 1945.

At autopsy the heart weighed 600 Gm. The mitral orifice was described as that of a "button hole." No pulmonary infarcts were found. Careful palpation of the lungs revealed about 20 spherical nodules of ossification. They had no capsules. These were found throughout all lobes of both lungs and were both deep and superficial. When a nodule was shelled out, close inspection showed that the surface was finely nodular, resembling the surface of a cauliflower.

Microscopically, there were severe acute bronchopneumonia and chronic passive congestion of the lungs. The alveolar walls were thickened by collagen and fibroblasts. Clusters of hemosiderin-laden macrophages were scattered in the alveolar spaces and walls. There was much proliferation of alveolar epithelium. Some of the alveolar walls had clublike thickening.

The nodules were composed of irregular cortical-like bone with cement lines, lacunae, and osteocytes. The bone was mature (fig. 2). Haversian canals were present. The cement lines were arranged in an irregular wavy concentric pattern. Small irregular spaces in the bone contained fibro-elastic connective tissue with osteoblasts and blood capillaries. No hematopoietic tissue was present. These nodules of heterotopic bone compressed and flattened the directly adjacent alveolar spaces, occupying an area equivalent to several alveolar spaces.

**Fig. 1.** Case 1. Note the characteristic mitral configuration and the multiple nodular densities.

**Case 2.** I. S., a 29-year-old clerical worker, was first seen in the University Hospitals in November 1941 at the age of 22. The cardiac diagnosis was rheumatic mitral stenosis. An x-ray of the chest showed occasional nodular densities in the lungs and left atrial enlargement. Calcification was seen in the mitral valve at fluoroscopy. He died 7 years later after continued episodes of congestive heart failure and a final bout of acute bronchopneumonia.

At autopsy the heart weighed 650 Gm. The mitral valve was sclerotic and stenotic, measuring 1.2 cm. by 5 mm.

Microscopic examination of the lung demonstrated severe confluent acute bronchopneumonia and chronic passive congestion. Some sections showed thickening of the alveolar walls by collagen and fibroblasts with epithelial proliferation. Emphysematous changes were seen in other areas. Clusters of hemosiderin-laden macrophages occurred in groups of adjacent alveolar spaces and just beneath the pleura. Mature, but irregularly patterned, cortical-like bone with cement lines, lacunae, and osteocytes was demonstrated in the lung parenchyma. No bone marrow was seen.

**Case 3.** B. M., a 36-year-old housewife, was first examined in January 1954. The cardiac diagnosis was rheumatic mitral stenosis. Congestive heart failure had been present for at least 2 years. A chronic cough productive of one-fourth cup of greenish mucopurulent sputum daily had been noted since childhood. This followed recurrent episodes of pneumonia. Cardiac fluoroscopy revealed 1+ right and left ventricular enlargement with a prominent pulmonary artery segment and 1+ left atrial enlargement. Bronchovascular markings were increased bilaterally. No nodular densities were seen in the lung fields. Cardiac catheterization was done on February 5, 1954 (table 2). On February
9, 1954, the patient had a left thoracotomy and mitral commissurotomy. The left lower lobe and lingula showed far advanced bronchiectasis. The left upper lobe was very emphysematous. The surgeon estimated the mitral valve to be 3 mm. in diameter. The commissures were calcified. After valve fracture, the estimated opening was about 2.5 cm. in diameter. Postoperatively, her general condition deteriorated with increasing respiratory insufficiency. She died 12 days after operation.

The heart weighed 400 Gm. and was covered with a thick shaggy “bread and butter” fibrinous pericarditis. The mitral valve was still stenotic and the chordae tendineae were very thick, short, and stubby. The appearance of the right middle lobe suggested pulmonary infarction but no thrombus could be found. Microscopically, the lung tissue revealed acute necrotizing bronchopneumonia and edema. A small piece of mature heterotopic bone was found occupying an area equivalent to 5 or 6 alveolar spaces. There was mild thickening of the alveolar wall. A few areas of alveolar epithelial proliferation were found. No marrow tissue was seen.

Case 4. E. R., a 27-year-old hair dresser, was admitted to the University Hospitals on January 8, 1958. A diagnosis of rheumatic heart disease with mitral stenosis, possible mitral insufficiency, and congestive heart failure was made. A chest film revealed several circular “calcific lesions” scattered throughout the middle and lower portions of the right lung field. Bilateral bronchograms were normal. Cardiac catheterization showed no evidence of an intracardiac shunt. Moderately severe pulmonary hypertension was found (table 2). Pulmonary function studies were normal (tables 2 and 3). A mitral commissurotomy and a lung biopsy were done on January 29, 1958. The mitral valve was calcified anteriorly. Moderate mitral regurgitation was present. The posterior commissure was opened and the valve orifice was increased in diameter from 1 cm. to 2 cm. Eight weeks post-

Fig. 2. Case 1. Nodules of cortical-like bone are surrounded by areas of acute bronchopneumonia superimposed upon a background of chronic congestion of the lung parenchyma. Hematoxylin-eosin stain.
DISSEMINATED NODULAR PULMONARY OSSIFICATION

TABLE 2.—Cardiac Catheterization and Arterial Blood Studies

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Pressure (mm. Hg)</th>
<th>Oxygen saturation (%)</th>
<th>Pco₂ (mm. Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right pulmonary</td>
<td>Right pulmonary</td>
<td>Femoral artery</td>
</tr>
<tr>
<td></td>
<td>artery &quot;wedge&quot;</td>
<td>proximal Mean</td>
<td>(air)</td>
</tr>
<tr>
<td>3</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Preop.</td>
<td>68/33</td>
<td>40</td>
<td>65/0/5</td>
</tr>
<tr>
<td>4</td>
<td>25/16</td>
<td>20</td>
<td>56/0/6</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>20</td>
<td>66/3/7</td>
</tr>
</tbody>
</table>

operatively, cardiac catheterization and pulmonary function studies were essentially unchanged (tables 2 and 3). In April 1958 he suddenly developed acute pulmonary edema and died. An autopsy was not made.

The specimen of lung biopsy consisted of 12 Gm. of lung tissue measuring 4.5 by 2.5 by 2.5 cm. It had a rubbery consistency and cut with moderate resistance. The pleura was slightly thickened but smooth and shiny. The specimen contained several white, stony hard, irregular but generally spherical nodules measuring 3 to 4 mm. in diameter. They were easily shelled out from the lung parenchyma. They appeared to be small fragments of bone.

Microscopically the lung parenchyma was mostly collapsed. There was severe chronic passive congestion of the lungs with thickening of the alveolar walls by collagen and fibroblasts. Numerous macrophages with hemosiderin granules were seen in the collapsed alveolar spaces. There was proliferation of alveolar epithelium. The arteriolar walls were thickened by intimal proliferation. Scattered throughout the alveolar walls were small ball-like masses of hyalinized fibrous tissue. The pattern of these masses with the fibrosis was consistent with old healed rheumatic pneumonitis. The pleura was thickened by collagenous tissue. The nodules were cellular but mature bone with poorly oriented cement lines, osteoblasts, and lacunae. The cement lines described an irregular concentric oval pattern. There were irregularly shaped small spaces that contained loose fibrocytic connective tissue with hemosiderin containing macrophages, osteoblasts, and small, thin-walled capillaries. There was no hematopoietic tissue.

DISCUSSION

In 1859 Wagner11 described bone formation in the lungs of a 26-year-old man with mitral stenosis, tricuspid stenosis, and aortic insufficiency. Similar findings were reported by Derischanoff,12 but Salinger13 was the first to stress the correlation between pulmonary ossification and mitral stenosis.

The incidence of discrete ossification in the lungs in chronic mitral stenosis is unknown. No statistical survey of this entity is mentioned in the previous reports. Our study of patients with mitral stenosis indicates that it is rare, since it appeared in only 4 of 708 cases.

The etiology of bone formation in the lung is not clear. Several theoires have been proposed. Salinger13 thought bone formation resulted from long-standing pulmonary congestion. Gross24 also believed that pulmonary venous congestion was the most important factor causing transudation of plasma and red cells into the alveolar space and organization by connective tissue. Calcification then was facilitated by hemosiderin and subsequently transferred to bone. This concept was not accepted generally. Fleming and Robinson5 found no evidence of pulmonary venous congestion in their 8 patients. No cases of bone formation have been reported in simple pulmonary congestion, although a few workers showed that venous stasis or general circulatory impairment favored bone formation in rabbit kidneys.27,28 Daugavietis and Mautner21 reported 1 patient with disseminated nodular pulmonary ossification and mitral stenosis, and hinted that chronic passive congestion of the lungs and damage to the liver by quinidine constituted the most likely cause. No other authors have described this combination.
interstitial pneumonia, usually and within connective tissue proliferation, forerunner. Chronic inflammation of the entity was thought to be similar to the bone. They believed that interstitial pneumonia, usually combined with chronic passive congestion, might well be the forerunner. Congestion facilitated transformation of the connective tissue into bone. Elkeles and Glynns proposed a similar hypothesis. They thought that the histologic appearance was similar to that seen in rheumatic pneumonia and that the bone nodules arose as a late complication. One of our cases (no. 4) had similar histologic findings. A majority of the reported cases, however, had not had rheumatic pneumonia. Furthermore, the entity of rheumatic pneumonia is not universally accepted. Neither of these hypotheses has received much support.

Englestad produced roentgen-ray pneumonia experimentally in rabbits and noted subsequent pulmonary ossification similar to that observed in mitral stenosis.

Haubrich thought hemosiderin deposition in the lungs promoted pulmonary ossification. Lawson and Ellman and Gee suggested that bony nodules were the end result of organization of hemosiderin deposits in the lung. They also believed that chronic passive congestion associated with pulmonary hypertension, small repeated hemorrhages, and hemosiderin deposits in clumps or macrophages were the important antecedent pathologic conditions. This explanation is not plausible, however, since bony nodules in most reported cases have only a small amount of iron.

Most patients with mitral stenosis and pulmonary ossification have at least histologic evidence of hemosiderosis. Focal accumulation of hemosiderin in phagocytes forms distinct nodules in the lungs. These nodules, when sufficiently large (1 to 3 mm.) become opaque, and may appear as miliary densities in the chest x-ray. Lendrum, Scott, and Park believed that both hemosiderosis and
Bone formation are the direct result of pulmonary hypertension and that hemosiderosis is produced by recurrent small pulmonary hemorrhages. The ossification then occurred in the fibrinous exudate of pulmonary edema, rather than as a direct result of hemosiderosis. Other authors supported the concept of a fibrinous alveolar exudate as the site of bone formation, although they agreed that there is uncertainty about factors responsible for the exudate and its subsequent ossification.

Another hypothesis is that thrombosed septal capillaries may protrude into the alveoli, or become completely detached from the alveolar walls. Mesenchymal cells, which attach to the capillary surface, may be associated with the formation of bone. All these ideas are based on histologic and morphologic appearances. Experimental studies on heteroplastic bone formation show bone that is produced through activity of young fibroblasts. Local calcium injection appears to stimulate ossification. Bone may be formed in old calcified lesions. Most cases with pulmonary ossification examined at autopsy had only bone formation but no unossified foci of calcification. Calcification does not seem to be a necessary precursor for bone formation. Even if it may be, transitional stages must be short and occur early in the disease.

It is unlikely that any of these factors alone is responsible. Combinations of 2 or more probably are necessary for the production of bone. Pulmonary edema, chronic passive congestion, and interstitial pneumonitis may be associated with other types of valvular disease. However, disseminated nodular pulmonary ossification has not been described in the absence of mitral stenosis.

Alteration in lung function of patients with mitral stenosis has received considerable attention in the literature. In 1 of our patients pulmonary function tests were all normal (tables 2 and 3). No other report of pulmonary function in patients with nodular pulmonary ossification and mitral stenosis could be found. Badger, Gottlieb, and Gaenser found normal pulmonary function tests in a patient with alveolar microlithiasis.

The diagnosis of bone formation in the lung should not be too difficult when mitral stenosis is evident. Skin tests with proper agents, various blood chemistries, bacteriologic studies, and, in some instances, lung biopsy may be necessary to make the correct diagnosis.

Summary and Conclusions

We have described 4 new cases of disseminated nodular pulmonary ossification associated with mitral stenosis. This rare condition occurs predominantly in young men with mitral stenosis, pulmonary hypertension, and congestive heart failure. Radiologic examination shows multiple nodular densities throughout the lung fields. The pathologic findings consist of numerous discrete nodules of bone, measuring 2 to 8 mm. in diameter, and usually located within alveolar sacs or groups of adjacent air spaces.

Detailed lung function studies in 1 patient with this rare complication of mitral stenosis were normal. Cardiac catheterization findings in this patient and in 1 other patient with the same disorder showed severe pulmonary hypertension.

The pathogenesis of disseminated nodular pulmonary ossification is still unsettled, but we agree with the suggestions of others that pulmonary hypertension, interstitial pneumonitis, and congestive heart failure may be the necessary prerequisites for the combination of disseminated nodular pulmonary ossification and mitral stenosis.

Acknowledgment

The authors are deeply grateful to Dr. William B. Bean for his encouragement and editorial assistance, and to Dr. John R. Carter for review of the microscopic findings.

Summario in Interlingua

Nos ha describite 4 nove casos de disseminate ossification nodular pulmonar, associate con stenosis mitral. Iste condition es rar e occurre predominantemente in juvane masculos con stenosis mitral, hypertension pulmonar, e congestive insufficientia cardiac. Le
examine radiologic monstra multiple densities nodular in omne partes del campo pulmonar. Le constatazioni pathologic consists de numerose noduli discrete de osso, de diametres de inter 2 e 8 mm, usualmente locate intra sacco alveolar o in gruppos de adjacente spacios de aere.

In 1 paciente con iste rar complication de stenosis mitral, studios detalliate del function pulmonar revelava nulle anormalitate. Catheterismo cardias, in iste paciente e etiam in un altere con le mesme disordina, revelava sever hypertension pulmonar.

Le pathogenese de disseminate ossification nodular pulmonar remane indecise, sed nos nos trova de accordo con le suggestion presentate per altere autores que hypertension pulmonar, pneumonitis interstitial, e congestive insufficientia cardia es possibilemente requirimentos indispensabile in effectuar le combination de disseminate ossification nodular pulmonar con stenosis mitral.

REFERENCES

9. SHARP, M. E., AND DANINO, E. A.: Unusual form of pulmonary calcification: “Micro-

Medical Eponyms

By Robert W. Buck, M.D.

Basedow's Disease. The description of exophthalmic goiter which is considered classic by the Germans is that of K. Ad. von Basedow (1799-1854), a practicing physician in Merseburg. It appeared in Casper's Wochenschrift für die gesamte Heilkunde for March 28 and April 4, 1840, pp. 197-204 and 220-228. The article is entitled "Exophthalmos as a Result of Hypertrophy of the Cellular Tissue of the Orbit" (Exophthalmos durch Hypertrophie des Zellgewebes in der Augenhöhle).

"I have frequently observed exophthalmos caused by . . . a diseased condition of the cellular tissue of the orbit—a peculiar hypertrophy which seemed to arise as the result of disease of the heart and the larger blood vessels of certain glandular and other tissues.

"Fourteen years ago I first made the acquaintance of Madam G. when she was a nineteen year old girl. At that time she was still suffering from serofulous glands in the neck, but was otherwise well. She had an acute rheumatism which left as sequelae edema of the ankles, loss of weight, amenorrhea, palpitation and rapid small pulse, precordial distress, and dyspnea. Even at this time there was also, however, a definite protrusion of the otherwise healthy and visually normal eyeball so that the patient slept with the eyes open, had a frightened appearance, conducted herself in a careless and lively manner, and soon had the reputation of being a little mad.

"Coincident strumous swelling of the thyroid gland led me to suspect a similar intumescence of the cellular tissue behind the optic bulb and suggested the use of iodine and digitalis, whereupon an improvement in all her symptoms resulted . . . although she still showed an unhealthy pallor and her eyes were unnaturally wide open and prominent."

After detailing the typical symptoms of hyperthyroidism in four other cases, he concludes:

"Having given it as my opinion that the immediate cause of exophthalmos is a strumous hypertrophy of the cellular retrobulbar tissue, I wish to amplify this by saying that I regard this hypertrophy as an incidental phenomenon, secondary to an abnormal condition of the circulatory system—a blood dyscrasia which, by reason of some as yet unknown serofulous taint, takes the form of glandular growths and tissue hypertrophy."
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