Excerpts from a Clinical Report and Autopsy by Professor Traube on a Patient with Lung Disease Caused by Coal Dust (1860)

Abstract

The excerpts from the clinical report and autopsy performed in 1860 by Professor Ludwig Traube (1818–1876) of Berlin's Charité Hospital on a fifty-four-year-old working-class patient suffering from lung disease reveal, in drastic detail, the effects of coal dust in conjunction with malnutrition and other circumstances typical for workers in the period of early industrialization. At the time, German medical science gradually came to understand the causes and symptoms of the respiratory disease known as black lung.

Source

I. Part 1

I believe that the following observations deserve to be reported, not only because they answer a question that has been pending for some time: whether or not coal particles are able to penetrate in larger quantities into the interior of the respiratory organ and accumulate in the pulmonary alveoli; but also because they relate to some general pathological questions, making important contributions to their eventual resolution. I shall therefore be forgiven for offering a more detailed account of the specifics that strike me as conclusive, and even of the accompanying circumstances.

Observation

H., laborer, 54 years old, was admitted to the Charité on October 21, 1860. For about twenty years he has been suffering from a cough with white sputum. Often times the cough would disappear completely; but given the patient's irregular lifestyle (he is by his own admission a drinker), it soon returned. For several years, he has also been afflicted by shortness of breath, which has manifested itself especially after more strenuous exertions. Haemoptysis or chest pain was reportedly never present when it happened. Patient used to submit to a bleeding every year around Midsummer's Day, though he has not done so the last 12 years. He states that he never sought medical attention at any time.

Three and a half months ago, supposedly as a result of hard labor during which the patient was continuously exposed to unfavorable weather, the cough and sputum—but especially the difficulty breathing—increased to the point where he had to give up his job. After several weeks, these complaints were joined by swelling of the legs. A doctor who was then summoned sent him to a hospital, but since the cough grew stronger, the sputum more abundant, and the difficulty breathing and the edematous swelling increased as well, he left again after only 4 weeks. Back at home, feeling very faint and weak, he was confined to his bed all the time. After he had spent another 14 days in this state, without feeling any improvement in his sickness, on the contrary, the dropsy getting worse and spreading also to his upper body, he sought help at the Charité. There his condition is said to have improved quickly, even though he developed some bloody sputum about 8 days after being admitted. As the information I have obtained shows, the diagnosis at the time was a diffuse bronchial catarrh with pulmonary emphysema. The urine was free of protein. The dropsy was initially treated with various diuretics, without success. Eventually, with the use of a saturatio communis, there was an adequate diuresis. The disappearance of the hydropsy also diminished the cough, the sputum, and the difficulty breathing. Another ailment, a

swelling of the right leg caused by venal thrombosis, which had joined the chief complaint shortly after his admission, was also cleared up (by rubbing it with gray ointment and applying tinctura jodi).

Immediately after his release from the Charité, which occurred about 14 days ago, the patient noticed that the swelling of the legs and the body had come back, even though he had not returned to work. At the same time the cough and shortness of breath increased again, the sputum became more abundant, and the urine scantier. Soon the complaints got so out of hand that he was forced to return to the clinic; this time he was moved to my ward.

The examination performed on October 22 at noon showed the following:

A man, not large, of fairly powerful build, with a panniculus low in fat and a dirty pale color to the cheeks, little redness of the lips. Elevated dorsal position. Completely conscious. Patient complains of cough, shortness of breath, and swelling of the abdomen, which is combined with a feeling of tension. The skin of the trunk has a decidedly blue tint, which is even stronger in the lower extremities. Traces of previous ulceration on the right calf. Legs quite strongly swollen, the scrotum less so.

Chest with an abnormally strong arch; the anterior wall forms an almost spherical segment between the claviculae and the sixth pair of ribs. Seen from behind, the lower half of the chest appears broader than usual. Breathing type costo-abdominal with little movement of the ribs, strong protrusion of the abdominal walls and moderate contraction of the scaleni. Percussion sound at the anterior chest wall loud, fairly deep, not tympanitic. Along the right lateral wall the sound is the same on top, but higher further down. The lower boundary of the right lung lies at the parasternal line at the height of the sixth rib, at the axillary line at the height of the eighth rib; the lower boundary of the left lung at the axillary line also at the height of the eighth rib. In the back the percussion sound on both sides is muffled in the lower third. The auscultation in front reveals on both sides rasping (vesicular) respiration with whistling, the latter especially during exhalation, in the back an exceedingly faint, undetermined noise along the lower portions, occasionally with quiet whirring, in the upper half a purely rasping respiratory sound. Frequent coughing, especially in the horizontal position and thus, as the patient maintains, more frequent at night than during the day; but the cough supposedly disappears immediately if the patient sits up. Sputum, currently not present, is said to be fairly abundant.

The sound in the cardiac region is nearly as loud as at the corresponding location on the left side. Apex beat is absent. One notices only a faintly visible rising of the left nipple, which is located in the fourth intercostal sphere. The tones are pure and moderately strong. Heart palpitations not present, even though the cardiac action is irregular. Radial arteries noticeably sinuous, of medium thickness, their walls somewhat thickened, tension moderate, pulse fairly faint. The carotids likewise show a faint pulse. Strong swelling of the vena jugul. int. sinistra. Of the superficial veins, the jugulares externae laterales and anteriores and the lateral cutaneous veins of the rib cage are swollen, and their walls simultaneously thickened. The vena saphena dextra forms a thick, solid, cylindrical cord. Tongue somewhat bluish, cool, moist, minor coating. Abdomen markedly bloated, abdominal walls rather tense. Ascites with non-significant meteorism. The boundaries of the hepatic dullness cannot be precisely determined. Order: Infus. rad. Senegae (3ij) . . . Liq. Ammon. Anisat. 3j, Elaeosacch. Menthae crisp. 3j, 1 tablespoon every 2 hours.

Evening: pulse 112; respiratory rate 40; temperature = 36.7°

23 Oct.: slept little at night. Pulse 112; respiratory rate 32; temperature = 36.5°

Appetite good; 4 watery bowel movements since yesterday. Urine very sparse, reddish brown, clear, no sedimentation. Very severe, excruciating paroxysms of coughing. The sputum consists of a small number of gray, strongly translucent round lumps dotted with black spots, which contain, apart from numerous

corpuscles of phlegm, a substantial number of larger cells filled with black molecula and a strikingly large number of black particles not contained within cells. Without exception the black corpuscles show a sharply delineated, angular but very irregular shape. In part this circumstance, in part the considerable size of many of them gave me the idea that this was not black pigment, but possibly inhaled coal particles. When asked about his work because of this, the patient relates that from 1848 until three and a half months ago he was employed loading and unloading charcoal, that in doing this work he was constantly in a dusty atmosphere and frequently expectorated black sputum.

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On 25 October I subjected the sputum to another examination. It presents as a phlegmy, saliva-like liquid in which is suspended a large number of small yellowish flakes slightly different in shape, and numerous black dots of irregular shape that disintegrate under the pincers. Under the microscope the black dots show: a) in part large, cellular forms of the size and shape of pulmonary epithelia, in part smaller cells of the size of the phlegmy corpuscles, the majority of which contain larger, angular, black particles; b) in some places extensive groups of mostly large, angular, black particles, some of which are shaped like echinococcal hooks, but which also possess a variety of other forms and all of which are sharply outlined; c) a moderate amount of red blood cells that have turned pale. Most of the cells resembling the phlegmy corpuscles contain several small nuclei, up to as many as four.

The following observations were made between October 26 and November 4:

Lying on his back continuously with elevated upper body and difficulty moving. Because of the constantly increasing hydropsy, the patient is tormented by frequent, very violent, and long-lasting paroxysms of coughing, as a result of which the already significant difficulty breathing is considerably exacerbated. During the fits of coughing the otherwise non-significant cyanosis also became so severe that the face and neck turned a very dark blue. At the same time the patient complained about strong pain in the right side and about a feeling as though his body was about to explode. The sputum, always produced only after great effort and amounting to about 34 ounces in 24 hours, consists, as before, of a strongly translucent, cloudy, gray, saliva-like liquid, in which the mucopurulent flakes are becoming increasingly yellow, less translucent, larger, and more numerous, while the amount of the black spots remains fairly constant. The latter are found both in the liquid and within the yellow flakes and consistently show, under microscopic examination, a large number of the described black particles, the vast majority of which are not enclosed within cells. Particularly striking among the myriad forms presented by these in part very long, angular corpuscles are those that show one or two regular, circular openings—nearly always equal in size—in their interior, or variously-sized segments of such openings at the edge. Upon repeated examination, brownish particles tending towards red, otherwise the same, were also noted among the black particles.

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II. Part 2

The autopsy performed at noon on November 22 showed the following:

A body of strong build but very emaciated; face very gaunt with a strong yellowish tint. The subcutaneous connective tissue of the left calf infiltrated by pus, in some places soft as mush; the suppuration does not go deep anywhere. The right vena saphena is filled over its entire length with deep red clots, which adhere only a little in the upper part and are at the same time very brittle here; vena femoralis clear.

Pericardium almost completely grown together with the heart through a thick layer of newly formed connective tissue in which, in places, small tuberculi are embedded, though only in small numbers. Here

and there, especially along the anterior cardiac wall, the two layers that make up the connective tissue have between them crack-shaped gaps filled with hard, dry fibrous material. The heart is not significantly enlarged, the right chamber is slightly enlarged and moderately hypertrophied. The muscle tissue is rather flaccid and dark brown. The aortic valves are thickened, somewhat shortened, two of them grown together over a length of about 1½ *Linien* (unit of measure); on the chamber wall in the area of the noduli there are a few small, hard outgrowths. The same on the atrial surface of one of the cusps of the mitral valve. Pulmonary artery slightly enlarged, its walls, too, only slightly thickened.

A moderate amount of bloody liquid in the pleural sacks. The lungs, at many places connected with the pleura parictalis, show abundant, bloody fibrous tissue superimpositions at the lower sections, especially on the left. Both inflatable except for the somewhat reduced and deformed lower left lobe, which cannot be fully unfolded. Only two non-extensive areas are emphysematously disfigured, one is found at the anterior edge of the upper left lobe, the other on the lower right lobe. Below the pleura there are numerous and large groups of black spots, distinguished from the usual pigment spots in two respects: first, even in the region of the upper lobes, where the pleura is little thickened or not at all, they do not present themselves sharply contoured; second, they do not appear arranged like usual pigment spots along the course of the intercostal spaces. The transverse section of the lungs appears colored an even dark black, with the exception of a few small areas (which include the emphysematous sections of the usual pale appearance); it is consistently smooth, shiny, and as soft to the touch as that of normal parenchyma. When pressed it gives off everywhere, and in some places a very abundant, foamy, serous, black liquid which stains the fingers like the solution of a bad black ink. Nowhere are there traces of newly formed connective tissue or indurations. The bronchia, to the extent that they were examined with the knife, showed nothing substantially abnormal; because of the decomposition that had already set in, nothing reliable could be said about the nature of the mucous membranes; at any rate, there could not have been any substantial thickenings, since we know from experience that they resist the onset of decomposition. Sparse white phlegm in the trachea. Small, old blood clots in a few branches of the pulmonary arteries. The bronchial glands are enlarged, blackish, in places caseously degenerated.

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The examination of the black, watery liquid coming from the cut section, undertaken during the autopsy, showed the following:

a) all the myriad shapes of the black and red particles that presented in the sputum while the patient was alive;

b) spherical black bodies of different size, many of them 56 times larger than usual pulmonary epithelia, consisting of a dense aggregate of the described black particles, which could not be shown to have a distinct cell wall;

c) a few well-formed cells of the size and shape of pulmonary epithelia, in which could be seen, in addition to a nucleus of the same shape and size as those contained in pulmonary epithelia, smaller and larger, black, angular corpuscles, at times so long that they reached the size of the largest cell diameter;

d) extensive aggregates of entirely normal epithelia.

Later, when thin segments of the pulmonary parenchyma—which had lost their black content upon brushing—were also examined, the places thereon which had become completely translucent showed no trace of newly-formed connective tissue, as was expected based on the macroscopic behavior.

Epicrisis

I. My firm belief that in this case the black and reddish particles discovered in the pulmonary parenchyma

and in the sputum while the patient was alive are, at least for the most part, coal particles is based on the following facts:

a) On the circumstance that these particles are different—in every way, one can confidently say —from the pigment molecules that are found so consistently and in such large number in the lungs of adults, and so frequently in the typical catarrhal and pneumonic sputum.

In both types of sputum, the black particles are found almost exclusively in cells, are always very small in size, and never have the irregular, angular shape described above. Identical in makeup are the mostly free granules (i.e., not enclosed in cells) that are found in the sputum in melanotic pulmonary phthisis. It was the behavior of the black particles in the sputum of our patient when I first examined him, which was so different from these, that gave me the idea, as I have already mentioned, that they were coal particles. My view was bolstered when, through repeated examination, I saw more and more of these peculiar shapes I have described. Even a superficial look into the microscope reveals that the black pigment in the lungs itself does not behave differently from that which appears in the sputum in cases of catarrh, pneumonia, and melanotic phthisis.

b) A second fact is the empirical match between the black and red particles found in the sputum and the dust of the material which the patient was compelled to handle for twelve years. For immediately after the first examination of the sputum, I sent for charcoal briquettes from the place where the patient had worked. I examined the finest particles that were released by light shaking and knocking of the obtained fragments, which, logically, were most likely to resemble those that were inhaled by the patient because they were suspended in the atmosphere on account of their small size. As the attached table (which, like the other two, Herr Dr. Munk was kind enough to prepare) shows, the experiment provided striking confirmation of my suspicion. The match between these figures and those represented by the particles of the sputum could not be any greater. Unfortunately, I paid too little attention to the red particles, which is why they are not represented in the chart.

c) A third fact is the match between individual shapes in the sputum with drawings that we have of the wood cells of pinus sylvestris. The necessary information has already been included in the case history. Here it should be mentioned that the mentioned fragments with the round holes or segments of such are undoubtedly charred ray cells.

The explanation for the simultaneous occurrence of black and reddish particles in both the sputum and the pulmonary parenchyma does not strike me as difficult. The color of the latter results from the fact that their carbonization is not as advanced as that of the black particles. In fact, we can produce the same color differences in every piece of wood and paper, depending on how much or little we expose it to the effect of the flame.

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III. Moreover, it seems to me that no small importance attaches to the fact, repeatedly and precisely established by me postmortem in various pulmonary epithelia, that these same epithelia contained coal particles. This fact proves that it is entirely possible for foreign bodies to penetrate cells of the organism without causing their destruction or even perceptible changes in them. The question of how this introsusception came about does not appear to me difficult to answer. The particles driven by the inhaled air stream arrive in the alveoli with a certain speed, which is why they are easily able to penetrate the cell walls they encounter, especially since they are sharp and pointed bodies.

IV. Another question is this: Which part of the complex of symptoms described here was caused by the presence of coal particles in the pulmonary parenchyma? At his admission, the patient claimed that he had been suffering from a cough and sputum for twenty years. Since he did not start working in the coal

dust until 1848, those manifestations can be related only to a simple catarrh that was already present before this time. Interpreting the shortness of breath is already more uncertain, since it did not join the cough and sputum until later. It is possible that the patient might have been able to provide more precise information about the time this manifestation appeared; unfortunately, I neglected to ask him about it. The illness that afflicted him three and a half months before his admission was, as the autopsy determined, a pericarditis, later complicated by a bilateral pleuritis. This affection was undoubtedly the source of the orthopnoea, the irregular heart action, the changes presented by the urine, the cyanosis, and the hydropsy. For these are manifestations that have been frequently observed in simple cases of insidious pericarditis. Of the symptoms that can be related to the accumulation of coal particles in the pulmonary parenchyma, we are thus left only with the peculiar cough, my explanation for which is that as a result of the increased secretion of fluid in the pulmonary alveoli, coal particles were being constantly driven into the bronchia, where they had an irritating effect on the mucous membrane because of their angular and pointy shape. Of course, this explanation presupposes that the reflex movements of the cough cannot be triggered by the pulmonary parenchyma, but that does in fact accord with other clinical facts. The explanation for why the cough stopped at the end seems to me to be that under the influence of the increased intestinal secretion, the abnormal secretion in the pulmonary alveoli was arrested. In fact, the sputum became very sparse precisely around that time.

V. Another question of clinical importance is whether exposure to a dusty atmosphere is sufficient by itself to cause the accumulation of particles in the pulmonary alveoli. If one considers how many people spend all their time in such an atmosphere without presenting any manifestations that their respiratory apparatus is affected, the assumption virtually thrusts itself upon us that this condition must be joined by a second one. The circumstance emphasized above, that our patient had been suffering for some time from a bronchial catarrh when his work at the coal yard began, seems an indication to me that a disturbance in the mechanism of ciliary action may be this second condition, in that either the movement of the cilia is impeded by the coating of phlegm, or their effectiveness is reduced because of deficient alimentation of the cells that carry them.

VI. Finally, one may note the similarity of the condition presented by the lungs in this case with the condition described by various authors under the name “black pulmonary edema.” If memory serves me right, I myself have seen about three cases of the affection. In all of them, not only was the parenchyma uniformly black in color, but the liquid that flowed from its transverse section was also colored black, from which one must conclude that the coloring particles in this case, as well, were, at least in part, only loosely contained in the pulmonary alveoli. It is possible, then, that the “black pulmonary edema” is also caused by the congestion of the pulmonary alveoli with coal particles.

The following should be noted with regard to the attached illustrations: 1) they contain only the forms of the coal particles in the sputum, from the lung, and from the dust of the obtained coal that seemed most characteristic vis-à-vis the usual black pigment; 2) several of the particles depicted on Plate I (as Fig. a and b) and Plate III (as Fig. a, b, c) presented a reddish-brown instead of a black color.

Source: Part 1: “Ueber das Eindringen feiner Kohlentheilchen in das Innere des Respirationsapparates. Von Professor Traube,” *Deutsche Klinik*, vol. 12, no. 49 (1860), pp. 475–78; Part 2: “Ueber das Eindringen feiner Kohlentheilchen in das Innere des Respirationsapparates. Von Professor Traube,” *Deutsche Klinik*, vol. 12, no. 50 (1860), pp. 487–90 (conclusion of no. 49).

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